LEED Performance Evaluation Plan

Seattle Justice Center & City Hall

December 31, 2003

Seattle Public Utilities

Prepared for
The City of Seattle

Prepared by
Paladino & Company, Inc.

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Executive Summary

The City of Seattle and Sustainable Building

In 1999 the City of Seattle adopted a policy that directs City funded projects over 5,000 square feet to achieve a Leadership in Energy and Environmental Design™ (LEED) Silver Rating from the LEED Green Building Rating System™ that was developed by the United States Green Building Council (USGBC).

To date, the City has a portfolio of 16 projects, slated to earn a LEED Silver rating or higher, equaling over $700 million of capital development and over 2.8 million square feet of space. The City has completed six of its first LEED Silver building projects. The rest are in the process of design and construction.

The Performance Evaluation Plan

The City's portfolio of LEED projects creates a unique opportunity for comparative evaluation of building performance and measured results. Such an evaluation will help the City determine how well it is doing in relationship to its other facilities, and reveal how LEED is benefiting the City and the region. In addition, local and national partners in sustainable building are eager to learn from the City's experience. The results of an evaluation program will become a useful education and marketing tool and will be shared.

The purpose of the evaluation plan is to provide data that will allow staff to assess the performance of LEED criteria. This will aid in the identification of lowest cost options, application of LEED to various project types, and ongoing tracking of operational costs and issues.

Data obtained will be used to assess the overall costs and benefits of the policy. It will also allow the City to monitor and evaluate its LEED project portfolio as an investment. In addition, the Evaluation can be used to connect LEED performance with the City's core values and sustainability goals, such as mitigating global warming, augmenting the urban forest, diverting construction waste from the landfill, creating sustainable communities, supporting healthy neighborhoods, etc.

Seattle 2002

Justice Center

City Hall

The objectives for the LEED Evaluation Program are:

▪ Measure and evaluate the benefits and costs of the City of Seattle's investment in LEED.

▪ Work collaboratively with other departments to create a set of sustainable building indicators.

▪ Create a triple bottom line approach to building evaluation.

▪ Develop results for communication with elected officials, managers, and the private sector.

▪ In Phase One, evaluate City Hall and Justice Center. Add other projects over time.

In order to obtain more detailed information on the benefits of LEED construction, the City's Green Building Team started the Performance Evaluation Project. This project was funded as a collaborative project between the Office of Sustainability and Environment (OSE), Seattle Public Utilities (SPU), Seattle City Light (SCL), Seattle Fleets and Facilities Division (FFD), and the Department of Planning and Development (DPD). A subcommittee of the City Green Building Team, the Evaluation Team, oversees this project with City staff from the various departments as shown in Table 1.1.

Table 1.1: City of Seattle LEED Performance Evaluation Subcommittee

Department	Representative
Seattle Public Utilities	Lucia Athens (Sub-Committee Chair)
	Emiko Takahasi (Drainage Economist)
Seattle City Light	Dennis Pearson (Energy Analyst)
	Peter Dobrovolny (Sustainable Building)
Department of Planning	Michael Aoki-Kramer (M&V Issues)
Fleets and Facilities	Joe Garcia (Building Operations)
	Amanda Sturgeon (Sustainable Building)
Office of Sustainability and Environment	Richard Gelb (Sustainability Indicators)

The goal of the team was to create a Performance Evaluation Plan that would provide the City with quantitative and qualitative data about the benefits realized in the completed projects. Paladino and Company, Inc. (Paladino) was hired as the technical consultant, to facilitate selection of indicators, design the evaluation protocol, and manage the data collection process. The team then conducted brainstorming and evaluation sessions to create a list of potential indicators, and selected the projects that will be measured in the initial study.

Initial Building Study Group – Justice Center & City Hall

There is limited funding available for in-depth analysis of the City's LEED projects. Therefore, the initial evaluation will study two of the projects completed as of September 2003, Seattle City Hall and the Seattle Justice Center. More projects will be added over time as funds become available.

These projects are representative of the office building type that will be of most interest to the private sector, and both have similar occupancy schedules and use profiles. Refer to Section 2 for a description of each building and its sustainable design features.

The results of the study of the two buildings selected for the initital study represent a small sample, but as additional Seattle projects are added or studies by other organizations implementing LEED become available, this data can become a part of a statistically significant data set relating to the costs and benefits of sustainable building. In the meantime, the study of the Justice Center and City Hall provide valuable information critical to informing future Seattle projects, and laying the foundation for ongoing study across the City's entire LEED portfolio.

Table 1.2: City of Seattle LEED Building Portfolio

Project Name	Department	Project Manager	Building Area [SF]	Estimated Certificate of Occupancy Date	Total Project Budget
Seattle Justice Center	Fleets & Facilities	Jun Quan	300,000	Complete	$92,000,000
Seattle City Hall	Fleets & Facilities	Monica Lake	198,000	Complete	$72,000,000
SW Precinct	Fleets & Facilities	Teresa Rodriguez	30,000	Complete	$11,000,000
Key Tower Remodel	Fleets & Facilities	Dove Alberg	1,240,000	12/31/06	$33,000,000
Park 90/5	Fleets & Facilities	Paul Berry	182,000	03/15/04	$31,000,000
Marion Oliver McCaw Performance Hall	Seattle Center	Jill Crary	295,000	Complete	$125,000,000
Fisher Festival Pavilion	Seattle Center	Bonnie Pendergrass	24,000	Complete	$9,300,000
North Cascades Environmental Learning Center	Seattle City Light	Mary Junttila	31,000	TBD	$15,000,000
Central Library	Seattle Public Libraries	Alex Harris	414,000	03/09/04	$155,651,000
Cedar River Treatment Facility Ops Building	Seattle Public Utilities	Liz Kelly	4,800	07/01/04	INA
Northgate Community Center & Library	Parks & Recreation	Tim Motzer	27,957	10/01/05	$6,186,000
Yesler Community Center	Parks & Recreation	Toby Ressler	40,000	12/31/04	$6,636,000
Joint Training Facility	Fleets & Facilities	Martha Turnbull	TBD	TBD	$28,000,000
Arctic Building Remodel	Fleets & Facilities	Jun Quan	TBD	2005	$9,000,000
Carkeek Park Environmental Learning Center	Parks & Recreation	Dan Johnson	1,700	Complete	$760,000
Highpoint Community Center	Parks & Recreation	Dan Johnson	18,000	03/01/04	$3,700,000
Totals			2,806,457		$598,233,000

Evaluating Performance

Environment

Economy   **Equity**
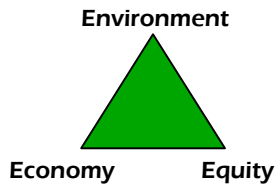
The Triple Bottom Line looks at a wider spectrum of influence by including the environment and people in the conventional financial equation.

The Triple Bottom Line

The benefit of sustainable building goes beyond the traditional economic model. In reality, there are often environmental and societal benefits as well as monetary ones. Thus there is a need for a new analysis model that looks at all three areas, or the 'Triple Bottom Line'. The sustainable development field has adopted this concept coined by John Elkington, co-founder of SustainAbility, and author of <u>Cannibals with Forks-The Triple Bottom Line of 21st Century Business</u>. The concept maintains that society depends on the economy, and the economy depends on the regional ecosystem, whose health represents the ultimate bottom line. The industry also refers to this concept as the three E's of Sustainability: Economics, Environment and social Equity.

Sustainable LEED buildings are designed to conserve resources, which can result in economic benefits such as reduced costs from lower energy and water consumption and reduced fees from construction waste recycling. Related environmental benefits include reduced emissions associated with energy production or vehicular transportation, improved salmon habitat or improved indoor air quality for workers.

High quality daylit environments interiors at Justice Center and City Hall can result in higher employee satisfaction and effectiveness.

Some sustainable strategies such as access to daylight bring benefits to the people who work in the building. This can result in reduced absenteeism and higher workplace satisfaction. Studies by William Fisk of the Lawrence Berkeley National Laboratory indicate that building strategies such as increased air quality and ventilation rates, and daylighting have a positive correlation with increased worker effectiveness. More comfortable employees also result in fewer comfort complaints, and less human resources time responding to complaints. A healthy work force and a healthy ecosystem are both indicators of a long-term pattern of sustainable development.

In addition to benefits directly or indirectly realized by the City and by employees in the two buildings, there is an additional social value to sustainability and LEED buildings. Dan John, the City's project manager for the Carkeek Park Environmental Learning Center, describes the process he hopes will result from student tours though the Center. Students visit the park and view the interpretive panels, watch salmon spawn in the creek, and learn about elements of the building that are better for the environment, such as low-impact gardening or using solar panels on the roof to generate power.

In turn, students talk to their parents about what they learned that day, and a certain percentage of parents might choose a more environmental option the next time there's an opportunity.

Sustainability and LEED act as an education platform, providing compound benefits to the community.

Choosing the Right Indicators

An Indicator is a measurement that can be used to assess progress and benefits that accrue to the triple bottom line. Once progress is assessed, indicators can be used to guide or motivate future action and educate others about the effectiveness of current efforts. By looking at how the City's sustainable building projects are performing, the City will have key data to use when making decisions regarding future City projects, as well as building policies, regulations, and incentives.

Sustainable Measures is a non-profit organization that provides tools and resources to others wishing to measure their progress toward a sustainable economy, society and environment. Their Guide to Sustainable Community Indicators offers the following criteria for effective indicators:

1. Relevant, for policy makers, businesses, residents, etc.

2. Statistically measurable

3. Logically or scientifically defensible

4. Reliable, e.g., are measured consistently over time

5. Leading, i.e., provide information while there is time to act

6. Attractive to the local media

Buildings are complicated systems, with a host of measurement possibilities. The goal of the Evaluation Sub-committee was to select indicators that would be the most useful, and that would relate to issues that the City places as a priority such as informing public policy and incentives. The Mayor's 2003 Environmental Action Agenda provided direction in developing the Indicators.

First, create a lean, green city government, reducing human and environmental risks, lowering operating costs through resource efficiency and waste reduction. Second, create healthy urban environments that restore ecological function and promote environmental justice through more sustainable approaches to managing the built environment, urban forest and green spaces. Finally, promote smart mobility by improving mobility options, environmental quality and social equity through smart transportation services and solutions. Indicators that would inform these efforts, and serve to measure their progress would receive a high priority. Thus a set of criteria was developed for use in evaluating possible indicators.

City Hall

1. Supports the Mayor's Environmental Action Agenda goals

2. Clear link to developing policies and incentives

3. Accessible, measurable and reliable data

4. Available baseline

5. Aligned with a LEED credit

Table 1.3: LEED Performance Evaluation Indicators

Performance Indicators	
Environmental	1. Stormwater Quality
	2. Stormwater Volume & Peak Flow
	3. Potable Water Use
	4. Energy Use
	5. Emissions Associated with Energy Use
	6. Construction Demolition and Land-Clearing Waste
	7. Recycled Content Materials Used
	8. Interior Air Quality
Social	9. Comfort complaints/Year
	10. Absenteesim Rates
	11. Employee Turnover Rates
	12. Access to Daylight
	13. Visual Comfort Conditions
	14. Thermal Comfort Conditions
	15. Perceived Worker Effectiveness
	16. Workplace Satisfaction
Economic	17. Water Cost
	18. Energy Cost
	19. Staff Overhead Costs, Related to IEQ
	20. Net Present Value of First Cost Increment and Savings

The Evaluation Team brainstormed a list of possible indicators. Subsequent discussion and investigation revealed whether an established baseline against which to measure progress existed, along with accessibility and measurability of required data. Further review resulted in prioritization based on the set of selection criteria. The final selection process resulted in a refined set of indicators, as listed in Table 1.3. The Evaluation Team would like to measure all 20 indicators, should funding be made available.

Other Indicators

Through the course of reviewing potential indicators for this study, several were identified that are of interest, but are difficult to measure or beyond the scope of this study.

1. Social Capital Development

2. Accessibility to Diverse User Groups

3. Community Support

4. Asset Value Protection

5. Exterior Air Quality

6. City Employee Vehicle Miles Traveled

7. Ozone Health due to Refrigerant Use

8. Burden on Municipal Water Treatment Plants

9. Market Transformation

10. Public Goodwill

11. Crime Prevention

12. Materials/Labor Savings due to Raised Access Floor Flexibility (City Hall)

13. Sound and Noise Reductions due to Double Skin Wall (Justice Center)

14. Facilities Maintenance Costs and Savings

These may be discussed or tracked in an informal fashion. For example, the civic campus, on which these two buildings sit, contributes to increased public open space, which could also be considered Social Capital Development. This benefits residents and visitors to the City, but is difficult to quantify and measure.

In the case of Facilities Maintenance, no baseline data exists, so determining a delta in the new buildings would be difficult. Tracking Facilities Maintenance costs associated with various green design features would be useful information to help determine life cycle costs of those features. Such data may be collected in the future if funding allows.

Collaborative Approach

The triple bottom line approach addresses three different types of indicators: economic, social, and environmental. For this reason, key liaisons have been developed with appropriate City staff that provide expertise related to each of the three indicator types. These staff will provide input and review on both the design and implementation of the evaluation plan. Liaison staff are listed in Table 1.4.

Table 1.4: Liaison Staff

Indicator Category	Liaison Department	Representative
Project Coordinator	Seattle Public Utilities	Lucia Athens (Green Building Team Chair)
Social	Personnel Office	Sharon Tanberg (Safety Issues) Bill Budd (Safety Issues)
Environmental	Seattle Public Utilities	Emiko Takahashi (Drainage) Tim Skeel (Water) Shirli Axelrod (Solid Waste)
	Seattle City Light	Dennis Pearson (Energy) Jack Brautigan (Climate)
	Office of Sustainability and Environment	Environmental Coordinating Committee
Triple Bottom Line	Office of Sustainability and Environment	Richard Gelb Mike Cox
Economic	Department of Finance	Greg Hill

Justice Center

*CBE is conducting a thermal analysis of the double skin wall. **Above:** Double skin wall of Justice Center. **Below:** Researcher setting up equipment at the Justice Center.*

Data Collection

Measuring the selected indicators will involve effort by several different entities, included various departments of the City and outside consultants. These include:

- Fleets and Facilities Maintenance Staff
- Personnel, Citywide Safety Office
- Seattle Public Utilities
- Seattle City Light
- Paladino & Company, Inc.
- Berkeley's Center for the Built Environment
- J.H. Heerwagen & Associates, Inc.
- BetterBricks Daylighting Design Lab Seattle

Following measurement and analysis of the data from all parties, results will be presented in a Performance Evaluation Report by Paladino.

In the early stages of occupancy many components are fine tuned and adjusted until they are working as intended. To account for this, measurement and data collection for major systems, such as water and energy systems, at City Hall and the Justice Center would commence once the buildings have been fully occupied for at least six months.

Measurements In Progress or Completed

Several studies are underway as part of separate but coordinated efforts, and relate to the indicators selected by the Evaluation Sub-Committee. For example, the Center for the Built Environment (CBE) is conducting its own study of the Justice Center double skin wall. The CBE researches high-performance building technologies and is interested in performance characteristics of the thermal buffer wall. Thermal performance and interior comfort data will be shared with the City, and can be used to corroborate energy measurements and modeling by other consultants.

The BetterBricks Daylighting Design Lab Seattle (DDL) in Seattle is performing daylighting studies, with participation by Paladino. The DDL has already performed a daylighting and visual comfort study at the Justice Center. A similar study of the Municipal Building has been completed, as a measure of pre-occupancy conditions for the City Hall. A daylighting study is planned for City Hall as part of a graduate school class at the University of Washington.

Finally, J.H. Heerwagen & Associates, Inc. has been contracted by the Fleets and Facilities Division to conduct a pre- and post-occupancy survey of City Hall employee attitudes and perceptions about their work environment. The survey data will be augmented by the DDL daylight studies mentioned above and by City Safety Office baseline and post-occupancy data related to air quality.

Measurement Methodology

Each indicator selected requires a baseline against which to measure performance. Where multiple baselines exist, such as the LEED baseline of ASHRAE 90.1-1999 or the Seattle Energy Code for energy optimization, the baseline required by Seattle jurisdiction was used. Therefore, any benefits associated with LEED Silver projects is the benefit above what would have otherwise occurred with Seattle standard practice. Since the Seattle Energy Code is more stringent than the LEED baseline, only the delta between Seattle code compliance and total project energy savings would be considered. Various City departments also have individual standards and guidelines that may exceed code requirements; however this study will look only at requirements that apply to all Seattle projects.

Table 1.5 lists each indicator, along with contributing components and the organization leading the measurement or data collection efforts. For example, the indicator of Energy Use is measured against the performance of 5 components: the savings from the double skin wall (Justice Center only), HVAC

improvements, energy-efficient lighting and lighting controls, and underfloor air distribution (City Hall only). Paladino is listed as the Data Coordinator, and will both conduct measurements and receive and analyze incoming data from other sources. Data sources, and measurement methodologies for each indicator are presented in Section 3: Data Collection Methodologies.

Table 1.5: LEED Performance Indicators – Including Components & Leads

LEED Performance Indicators & Components				
		Indicator	**Component**	**Data Coordinator**
Environmental	1.	Stormwater Quality	Water Monitoring	Seattle Public Utilities
	2.	Stormwater Volume & Peak Flow	Water Monitoring	Seattle Public Utilities
	3.	Potable Water Use	Irrigation Use	Paladino
			Interior Fixture Use	Paladino
	4.	Energy Use	Double-Skin Wall	Paladino
			Improved HVAC	Paladino
			Energy-Efficient Lighting	Paladino
			Lighting Controls	Paladino
			Raised Floor	Paladino
	5.	Emissions Associated with Energy Use	From Energy Savings	Seattle City Light
	6.	Construction Demolition and Land-Clearing Waste	Materials Calculations	Seattle Public Utilities
	7.	Recycled Content Materials Used	Materials Calculations	Seattle Public Utilities
	8.	Interior Air Quality	CO_2 Concentration	Safety Office
			CO Concentration	Safety Office
			VOC Concentration	Safety Office
			Particulates Concentration	Safety Office
Social	9.	Comfort Complaints/Year	Facilities Data	Safety Office/FFD
	10.	Absenteeism Rates	Personnel Data	Personnel
	11.	Employee Turnover Rates	Personnel Data	Personnel
	12.	Access to Daylight	Measurements	Daylighting Design Lab
	13.	Visual Comfort Conditions	Measurements	Paladino
	14.	Thermal Comfort Conditions	Measurements/Survey	Paladino
	15.	Perceived Worker Effectiveness	Occupant Survey	Fleets & Facilities Division
	16.	Workplace Satisfaction	Occupant Survey	Fleets & Facilities Division
Economic	17.	Water Cost	From Water Savings	Paladino
	18.	Energy Cost	From Energy Savings	Paladino
	19.	Staff Overhead Costs, Related to Indoor Air Quality	Compiled from #9-11	Personnel
	20.	Net Present Value of First Cost Increment Savings	Compiled from #17-19	Paladino

Next Steps

Now that the LEED Evaluation Sub-Committee has selected a set of indicators and devised measurement methods for each indicator, planning is underway for the measurement process during 2004 and 2005. This is the heart of the Performance Evaluation Plan. Included in the planning is the search for funding, for measurements, reporting and subsequent education and outreach.

1. Funding: The Green Building Team Subcommittee is researching internal department funding as well as external funding sources. Once potential sources are identified, grants will be pursued to continue the City's study of sustainable building performance. The lessons learned by the City are vital information, both for future City projects and for the private sector.

2. Data Collection: With funding in place, data collection as outlined in Section 3 will commence in early 2004 and continue until late in 2005.

3. Performance Evaluation Report: Once data has been collected and measured, and the costs and benefits determined, the results will be published in a Performance Evaluation Report. An Interim report will be issued at the end of 2004, and the Final report at the end of 2005.
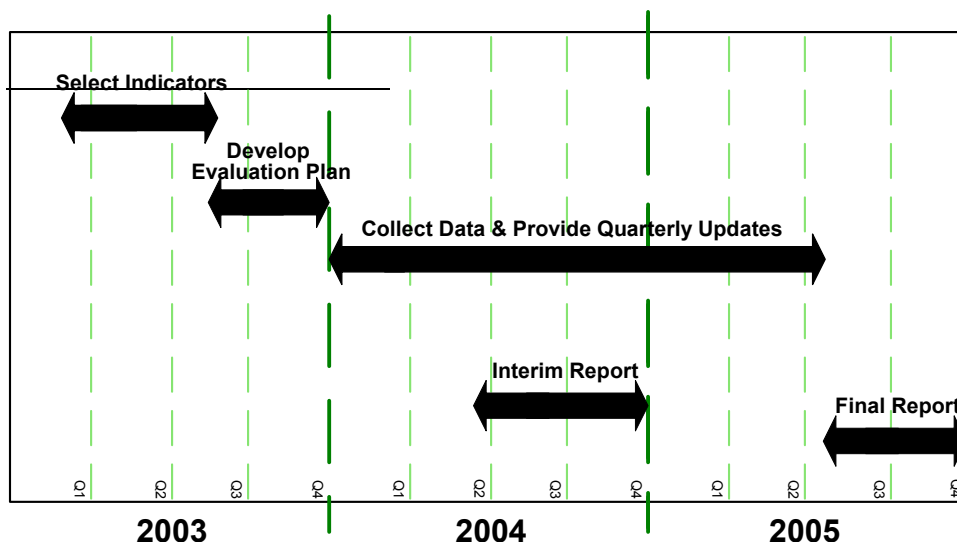
Figure 1.6: LEED Performance Evaluation Timeline

Study Group

Introduction

The two buildings that are being analyzed per the Performance Evaluation Plan are the Seattle City Hall and the Seattle Justice Center. Both projects incorporate a number of sustainable design features, building technologies and construction techniques that can be analyzed and evaluated. LEED was used as a tool in both projects and both were designed to attain LEED Silver ratings. However, LEED Applications are still in progress for both buildings, so all references to rating level are pending final review by the U.S. Green Building Council.

Provided in this section are project descriptions of the Seattle City Hall and the Seattle Justice Center that explain each building's sustainable design features and considerations. The indicator methodologies that will be applied to these buildings in 2004 and 2005 is explained in Section 3.

Seattle City Hall

Seattle Justice Center

Seattle City Hall

Project Description

Seattle City Hall, completed in July 2003, is located at 600 Fourth Avenue, in the heart of Seattle's Civic Center. Together with the adjacent exterior open space, an area of 200,000 square feet occupies seven floors above two floors of underground parking. Interior and exterior public gathering spaces, council offices, mayoral suite, council chambers and public reception areas are housed within the building.

A series of public spaces, both indoor and outdoor flow into a central lobby serving as Seattle's "front porch"- a gathering space fostering community participation. Transparency within the building represents openness and connection of the public to the civic realm. Views of the Puget Sound and the Seattle sky experienced are juxtaposed against a flowing water feature to create a vivid connection to the outdoors.

The City Hall has a structural concrete base surmounted by a six story steel superstructure. A steel brace frame is located around the building core to resist lateral forces. Concrete decks span between steel beams and have been lowered in places to accommodate a raised floor. The raised floor allows space for power, data and supply air to be routed to individual workstations.

Most employees occupying the new City Hall were previously housed in the Municipal Building. Several indicators in the Evaluation Plan will use data regarding conditions, such as comfort or indoor air quality, at the occupant's former location as a baseline for performance. Table 2.1 outlines where each department in the City Hall were formerly located.

City Hall -Lobby
The lobby of the City Hall acts as Seattle's "front porch" - providing access to natural daylight and views.

Green Roof
The green roof, as seen through low-emissivity fritted glass on the fourth floor, cleanses and reduces stormwater runoff.

Table 2.1: City Hall Tenants

City Hall Tenants	
Department	**Relocated From**
Seattle Channel (DoIT)	Municipal Building Basement
FFD Janitorial	Municipal Building Basement
Citizen Service Bureau (DON)	Municipal Building Floor 1
Legislative Department	Municipal Building Floors 9-10
FFD Property Management	Municipal Building Floor 2
Law Department	Municipal Building Floors 9-10
OIR	Municipal Building Floor 2
DOF and OPM	Municipal Building Floor 3 and Key Tower 24
Mayor' Office	Municipal Building Floor 12

Sun Shading
Exterior sun shading prevents unwanted heat gain from direct solar penetration.

Vertical Shade
Vertical fins on the north elevation bring light farther into the building, creating a visually dynamic façade.

Site Location and Reduced Impacts

The dense urban core of Seattle's Civic Center is located with convenient access to public transit, within walking distance of a variety of services and offers bicycle storage and shower facilities for 320 full-time building occupants. Vanpools are given priority parking and an electric vehicle recharging station is provided. Parking is located underground, maximizing the use of the building footprint. Site lighting is also designed to prevent direct illumination from obscuring the night sky.

Potable Water Reduction & Stormwater Treatment

To reduce the potable water demand low-flow plumbing fixtures, waterless urinals and drip irrigation were installed. Once the Municipal Building is demolished, the plaza portion of the site will be completed, including a rainwater storage system. Rainwater will be harvested and collected for landscape irrigation and toilet flushing, to further reduce the volume of potable water used in the building. A green roof composed of drought tolerant planting and a thin layer of soil absorbs and filters rainwater at a portion of the roof, reducing the volume of stormwater that requires treatment.

Energy Efficiency

High efficiency HVAC equipment was installed, including high efficiency water chillers, variable speed drive fans and under-floor air distribution. Commissioning is planned for the building systems; a systematic process to ensure that building systems (mechanical, lighting, electrical, etc.) perform interactively according to the contract documents and owner's operational needs. Direct-drive, permanent magnet motors reduces the electrical demand and emergency generator size.

Features such as large glazing areas, skylights and glass walls allow natural daylighting into the space, and are designed to minimize unwanted heat gains. Each unique elevation utilizes in various combinations-low-emissivity glazing, integral ceramic frit stripe shading, light shelves, and overhead shading to optimize energy performance and reduce energy consumption. High efficiency lighting is paired with natural daylighting to provide illumination when and where it is needed.

Material & Resource Conservation

A variety of recycled content, durable materials from local sources were installed in the Seattle City Hall. Materials such as concrete, steel, carpet, ceiling tiles, gypsum wallboard, restroom partitions and ceramic tile contribute to reduction of resource use. Concrete from the previous building was reused in both the concrete mix for the City Hall, as well as for shoring, to replace some of the new concrete. During construction, over 75% of the construction waste was diverted from the landfill.

City Hall was designed for a minimum of a 100-year life span through material choices, spatial layout qualities and the ability to accommodate updates in city services and future technology. The building layout allows flexibility for occupants, and barrier free design provides accessibility for all. Modular, adaptable work furniture and a raised floor system houses the underfloor air supply, electrical wiring and data cabling allowing ease of reconfiguration.

Indoor Environmental Quality

Low toxic adhesives, sealants, paints and coatings were used throughout the City Hall. Walk-off mats are located at major entrances to reduce the amount of contaminants that enter the building. Sources of pollution such as photocopiers and chemical mixing and storage are segregated and exhausted directly outdoors. To ensure high air quality, ventilation rates and flow are monitored and adjusted to provide comfort and healthy amounts of fresh air, with intakes far from contamination sources. During construction, a detailed indoor air quality plan was maintained, and the HVAC system was flushed out for a continuous two-weeks before occupancy.

Sustainable Materials
Materials were chosen for durability, adaptability and longevity, from a palette of locally available, recycled content sources.

Healthier Materials
Low toxic adhesives, sealants, paints and coatings were used throughout the building to ensure occupant health and worker satisfaction.

Seattle Justice Center

Justice Center Entry

Creating Public Spaces
The Courts are set back from the street to provide public spaces, representing the public nature of the building.

Project Description

The new Seattle Justice Center (SJC) replaces the Public Safety Building, located directly east of Seattle City Hall, in the core of Seattle's Civic Center. Completed in November of 2002, the 300,000 square foot civic space holds 800 full-time building occupants. The Municipal Court of Seattle and the Police Headquarters have been programmatically joined in the building, although spatially remain distinct. The primarily glassed southern part of the building houses the Courts and public areas, access to views and an extensive art collection, representing the public nature of the building. The Courts are set back from the street, creating a public plaza, and allowing natural daylighting and views to dominate both the interior and exterior experience. In contrast, the Police Headquarters are tucked into the north end of the building masonry, in a relatively conventional office configuration.

The structure of the SJC is a steel frame with concrete shear walls located around the building core that resist lateral forces. The HVAC system consists of a highly efficient variable frequency drive (VFD) chiller that supplies chilled water to air-handling units on each floor. The air-handling units supply individual variable air volume (VAV) boxes that contain a heating water coil supplied from a boiler on the 12th floor.

Justice Center employees were relocated from the Public Safety Building and the King County Courthouse.

Table 2.2: Justice Center Tenants

Justice Center Tenants	
Department	**Relocated From**
Seattle Municipal Court	Public Safety Building
Seattle Police Headquarters	Public Safety Building
King County District Court	King County Courthouse

Site Location

Location in Seattle's Civic Center provides convenient access to public transit, short walking distance to a variety of alternative modes of transportation and services. Bicycle storage and shower facilities are provided for employees.

Connect to the Outdoors
The public Municipal Court entry provides connection to the outdoors and a gallery for the Sustainable Arts Program.

Double-Skin Wall
The double skin wall is a high-performance solution that decreases energy use, which providing transparency that allows connection to the outdoors through daylighting and views to Puget Sound.

Potable Water Reduction & Stormwater Treatment

To reduce the potable water demand low flow toilets and plumbing fixtures were installed in the building and drip irrigation was installed in the plaza. Rainwater is harvested and collected for landscape irrigation. A green roof composed of drought tolerant planting and a thin layer of soil absorbs and filters rainwater, reducing the volume of stormwater that requires treatment. The largest portion of the planted roof is adjacent to the public outdoor terrace at the twelfth floor of the building, where it serves as a viewing area.

Energy Efficiency

The building features several HVAC upgrades, including efficient lighting, lighting sensors, and CO_2/demand ventilation. A double skin wall covers a large portion of the west facing façade, providing a buffer against heat gain from afternoon sun. The double skin wall is naturally vented and was designed to allow for the maximum amount of light to reach the interior of the space. Two independent planes of glazing are separated by an air space, with temperature-controlled louvers at the top. The louvers are automatically closed or open and either retain heat on cold days or vent heat on hot days. When open, air is drawn between the glazed planes from the bottom; the air then naturally rises, and is vented out at the top of the wall. The double skin wall reduces energy consumption while allowing for a great degree of glazing and transparency.

Material and Resource Conservation

A variety of recycled content, durable materials from local sources were installed in the Seattle Justice Center. Materials such as concrete, steel, carpet, ceiling tiles and gypsum wallboard contribute to reduction of resource use. During construction, construction waste was diverted from the landfill.

Indoor Environmental Quality

Exposure to natural daylight and views to the outdoors are provided to the large public lobbies and open offices situated near the double skin wall. Light shelves bounce help reflect light further into the space, and are incorporated into the double skin façade. This also helps to shade unwanted glare.

Adhesives, sealants, paints and coatings used throughout the Justice Center are all non-toxic. Walk-off mats are located at major entrances to reduce pollutants entering the building. Photocopiers and chemical mixing and storage are segregated and exhausted directly outdoors.

Healthier Materials
Low toxic adhesives, sealants, paints and coatings were used throughout the building to ensure occupant health and worker satisfaction.

During construction, a detailed indoor air quality plan was maintained, and the HVAC system was flushed out for a continuous two-weeks before occupancy with high efficiency filtration media.

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Data Collection Methodology

Methodology Introduction

This section outlines the components of each of the 20 indicators selected by the Evaluation Team and listed in Table 1.3. Data collection methodologies were developed specific to the 2 buildings identified for initial evaluation in 2004 and 2005, Seattle City Hall and the Justice Center. Each methodology is based on the individual buildings' equipment capabilities, available data collection mechanisms, existing baselines, and studies in progress or already funded. The data collected will be used to determine costs and benefits, both direct and indirect. Direct benefits, such as reduced energy and water costs, will be assessed. Indirect and qualitative benefits such as reduced absenteeism, worker productivity gains and employee retention rates will also be included.

Organization

The Indicators are organized by the triple bottom line impact categories. Each Indicator has a short list of key information such as the contact organization or department, data sources and measurement schedule. Next the Indicator is described along with the specific data methodology that will be used to track progress. The critical data points and equipment are listed in data collection tables and figures for each section.

Indicator Information Key

Data Coordinator: The City department or outside consultant coordinating the primary measurement or data collection efforts. The Data Coordinator may be responsible for providing the primary data, or measurements, or they may serve as a coordinator of several key data sources. Ultimately, Paladino will incorporate data from all listed sources into the quarterly updates and annual reports.

Contact Person: This is the person coordinating or providing data from the Data Coordinator department or company.

Baseline: The baseline information indicates the threshold against which actual conditions will be compared. Typically the baseline will be either Seattle code or conventional practice.

Supplemental Data: Outlines additional sources of data or other concurrent studies.

Start & End Measurements: Identifies the study period for each individual indicator, where determined. In general, the study period of each building will not commence until that building has been occupied for at least 6 months, to allow for the initial adjustments that building systems need at the beginning of occupancy.

Review Data: The schedule for downloading or taking measurements. Incoming data will be collected, and held for compilation and analysis in Quarterly Updates.

LEED Credits: Lists the LEED credits associated with the indicator. Refer to the Indicator Descriptions for notes on whether one or both of the buildings are pursuing the listed credit.

Data Collection

While some data collection efforts such as the pre-occupancy survey and daylighting measurements were initiated in 2003, the majority of the data collection will occur in 2004 and 2005. Data will be collected quarterly or as indicated in each indicator methodology.

A special Measurement and Verification (M&V) Plan has been designed to look specifically at energy and water consumption, including measuring key components of the HVAC systems. Refer to Section 4 for the M&V Plan. Refer to Section 5 for Performance Reporting Schedule.
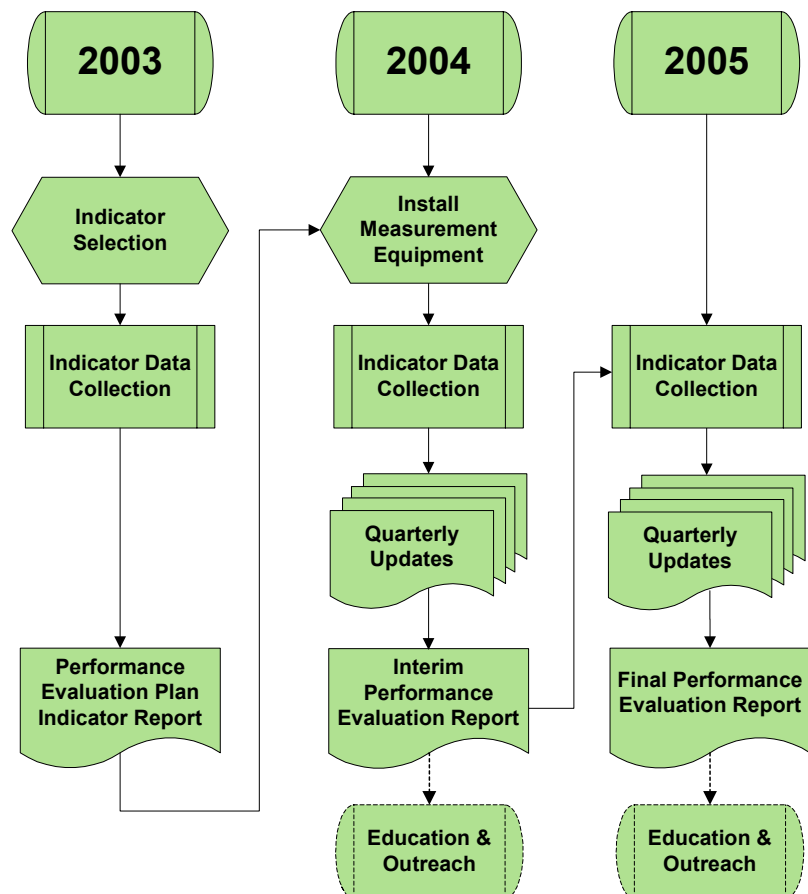
Figure 3.1: Seattle Performance Evaluation Flowchart

		Environment
#1	**Stormwater Quality**	Social Equity
		Economics

Indicator Information

Data Coordinator:	Seattle Public Utilities	**Start Measurements:**	1st Quarter 2004
Contact Person:	Beth Schmoyer	**End Measurements:**	Ongoing
Baseline:	Conventional Roof Run-off	**Review Data:**	Quarterly
Supplemental Data:	Monitoring Equipment SPU Water Sampling	**LEED Credits:**	Sustainable Sites Credits 6.1 & 7.2

Schedule

Indicator Description

The Stormwater Quality indicator is a measure of the water quality draining off the green roof, in comparison to water runoff from a conventional roof at the same building.

Both the Justice Center and City Hall have green roofs over a portion of the building roof area. The Justice Center green roof is 7,300 square feet, or approximately 30% of the roof area. Green roofs are a layered roofing system with a protective membrane on the bottom, plastic drainage layers, soil and then plantings on the top layer.

Green roofs have several benefits: protecting the membrane for longer roofing life, shading the roof to reduce cooling loads on the building interior, which results in energy savings, and stormwater run-off mitigation. The soils and drainage layer absorb a percentage of the rain falling on the green roof, and stores it to feed the plant roots. The soil and roots also act as a filter, removing particles and solids from the water. This results in better water quality for runoff entering the combined storm sewer.

Indicator Methodology

The design of the City Hall green roof included a separate green roof drainage system intended to facilitate water monitoring. 500 square feet of the green roof is isolated and drains separately for a distance, before joining with the rest of the roof runoff. However, due to the location of the isolated piping, above the lobby and above the corridor of the city council chambers, access to a sample tap would be challenging.

An alternative monitoring strategy is being considered. SPU is currently searching for a site where the green roof system used at the Justice Center and City Hall can be replicated for monitoring purposes. Samples of the study roof would be tested and compared to the runoff from the conventional roof at the Justice Center and City Hall. Determination of the water quality methodology is still in progress, as of December 2003.

		Environment
#2	**Stormwater Volume & Peak Flow**	Social Equity
		Economics

Indicator Information   Schedule

Data Coordinator:	Seattle Public Utilities	**Start Measurements:**	First Quarter of 2004
Contact Person:	Emiko Takahashi	**End Measurements:**	Ongoing
Baseline:	Engineering Calculations	**Review Data:**	Quarterly
Supplemental Data:	City Hall Rainwater Monitoring Program	**LEED Credits:**	Sustainable Sites Credits 6.1 & 7.2

Indicator Description

The Indicator is a measure of the amount of stormwater that is sent to the municipal stormwater system as compared to conventional stormwater management.

Both projects were built with combined stormwater runoff reduction strategies. The Justice Center has a green roof over a portion of the overall roof area. The project's stormwater detention tank was also oversized to store rainwater for irrigation use. City Hall also has a green roof covering a portion of the roof, and has a rainwater collection system to collect runoff from the roof and the ground-level plaza.

Green roofs help manage stormwater by collecting rainfall in the roof's drainage layer and soil. Some of this stored water is taken in by plants and released to the air through evapotranspiration. This reduces the amount of stormwater that is sent to the municipal stormwater system, which both reduces stormwater sewer fees and the burden on municipal treatment facilities. A cistern at City Hall will collect remaining stormwater run-off from the roof, and from the ground-level plaza. The cistern will be located below the plaza, in a portion of the previous Municipal Building basement. The collected water is filtered and then stored in tanks below the plaza for re-use in irrigation and toilet flushing.

The effectiveness of these stormwater management strategies will be studied to determine how well they perform in terms of gallons of water diverted and peak flows to municipal treatment facilities and combined sewer facilities.

Indicator Methodology

Seattle Public Utilities provided funding to the City Hall project for the rainwater collection systems; one of their key goals is to use performance data from this project to inform future policy and incentive decisions. Wood Harbinger Engineers and SvR design are currently assisting with a rainwater monitoring plan for City Hall, in conjunction with the civil engineer, SvR Design Company, and the architect, Bassetti Architects.

The plan will accommodate measurement of the water level in the cistern and any overflow. Sensors in the cistern will take measurements; data will be relayed to the DDC system, which can collect the

water data over time. This data, in combination with the remote water quality study listed under Indicator #1, will be used to assess the status of Indicator #2.

Although some rainwater is also collected at the Justice Center, the project was completed prior to the decision to monitor water collection. Therefore, only data from the remote water quality study will be available for analysis of this Indicator with respect to the Justice Center.

Data Collection Table – City Hall

Data Point	Equipment	Frequency
Building Water Use	Digital control	Monthly
Toilet Water Use	Submeter w/ digital output	Monthly
Irrigation Water Use	Sensor w/ digital output	Monthly
Conventional Roof Runoff	Not measured at this time	NA
Green Roof Runoff	Not measured at this time	NA
Total Flow into Cistern	Transducer Weir	Monthly
Cistern Level	Float with Monitor	Monthly
Cistern Overflow	Float w/ monitor or data loggers for 3 monitors	Monthly
Runoff Quality from Green Roof	Sample Tap	5-10 times/year
Runoff Quality from Cistern		5-10 times/year
Rainfall Data	SPU rain gauge Myrtle Edwards Park	Monthly

		Environment
#3	**Potable Water Use**	Social Equity
		Economics

Indicator Information

Data Coordinator:	Paladino and Co., Inc	
Contact Person:	Teresa Burrelsman	
Baseline:	LEED Water Calculations Use of Potable Water w/o Collection	
Supplemental Data:	City Hall Rainwater Monitoring Program	
	DDC Monitoring System	

Schedule

Start Measurements:	First Quarter of 2004
End Measurements:	Ongoing
Review Data:	Quarterly
LEED Credits:	Water Efficiency Credits 1, 2 & 3

Indicator Description

The Indicator is a measure of demand for potable water.

The City of Seattle is a major landowner, employer, building manager, fleet operator, utility owner and operator, consumer of goods and services and service provider and thus has leverage to promote water efficiency in the Puget Sound Region. It is committed to promoting water efficiency through its conversion to a model of clean, healthy, resource efficient, and environmentally responsible practices.

Potable water is typically used to irrigate the landscape and for all plumbing fixtures within a building. However, the City Hall Building and the Justice Center incorporate a variety of water-saving features, such as rainwater collection, drought-tolerant landscaping and water efficient fixtures.

Irrigation Use

Innovative landscape design, water collection practices and drought tolerant plants can drastically reduce or even eliminate the use of potable water for irrigation. At both the Justice Center and City Hall, native and drought tolerant plantings were used. In addition, at the Justice Center, the stormwater detention tank is oversized to allow storage of rainwater for irrigation purposes. At City Hall, rainwater will be collected in a cistern, and filtered and stored for both irrigation use and flushing toilets.

Interior Fixture Use

Water saving fixtures such as low-flow lavatories, low-flow showers and low-volume toilets and urinals have been installed that save water compared to code-compliant fixtures. In addition to efficient fixtures, City Hall will use some of the collected rainwater for flushing toilets.

Indicator Methodology

The LEED calculators for irrigation and fixture use will be used to establish expected water savings. These calculators use standard irrigation practices and standard code compliant fixtures as a baseline by which to compare potable water use. The City Hall rain water monitoring plan (see Indicator 2 Stormwater Volume) will have data on the amount of water that is collected from roof and plaza runoff, and on the volume of water used for irrigation and toilet flushing. Data on the total water use, toilet water use and irrigation water use will be collected via digital control meters installed at the building (see data collection table in Indicator #2) . This data will be used to refine the water savings calculations from the LEED calculator fro City Hall. Water savings will be expressed in gallons per year. See Indicator 17 Water Cost for associated dollar savings.

The Justice Center was completed prior to the development of the Evaluation Plan and the City's water monitoring goals. Therefore no monitoring equipment was installed at the Justice Center. The LEED Calculator will be the primary source of water consumption data, an estimate that will be adjusted to accommodate actual occupancy and schedule.

#4	Energy Use	Environment
		Social Equity
		Economics

Indicator Information

Data Coordinator:	Paladino and Co., Inc.		
Contact Person:	Teresa Burrelsman		
Baseline:	Seattle Code Bldg.		
Supplemental Data:	Building Energy Use – Dennis Pearson (SCL)		
	DDC Data – Ray Ely (Facilities Management)		

Schedule

Start Measurements:	2004
End Measurements:	2005
Review Data:	Quarterly
LEED Credits:	Energy & Atmosphere Credit 1

Indicator Description

The Indicator is a measure of the energy used at the buildings.

As a major institution in the area, the City of Seattle has leverage to promote energy efficiency in the Puget Sound Region. The City is committed to both promoting energy efficiency and to setting an example through its own use of clean, healthy, resource efficient, and environmentally responsible practices.

The baseline for this indicator is the energy that would have been consumed by the building had it been designed only to meet the Seattle Energy Code (SEC). While the LEED threshold is ASHRAE 90.1-1999, the SEC is more stringent overall and is required for any building built within Seattle's jurisdiction. Within the elements of the two standards, certain areas of the SEC are more stringent and some are less stringent than ASHRAE. However, no comprehensive study has been performed to establish a set comparison between ASHRAE and SEC with the U.S. Green Building Council. The energy savings comparison will differ from project to project, but the SEC typically results in between 10% to 20% savings over the ASHRAE baseline.

Energy used to operate a building represents the primary environmental impact of a building's operations. The cost of this energy is typically the largest building system operating expense. A well-designed, constructed and integrated building can save significant amounts of energy through climate responsive design and more efficient mechanical systems. Both City Hall and the Justice Center were designed with some degree of energy-efficiency. In order to gauge the effectiveness of the various energy-saving features included in the buildings, several key components will be studied through a Measurement and Verification (M&V) program. The key components are listed below.

Double-Skin Wall

A double-skin curtain wall was installed on the west face of the Justice Center. The wall reduces cooling demand by creating a thermal buffer of air between the interior and the exterior. The air in

between the glass also increases the insulation of the wall, and reduces conduction of heat and cold through the glass to the interior. It is designed to contribute to thermal comfort, by reducing occupant exposure to extremely cold or hot surfaces. The double skin wall is also expected to reduce cooling demand, resulting in less energy use.

Improved HVAC

As another energy saving strategy, Heating Ventilation and Air Conditioning (HVAC) systems were installed with efficiencies that exceed code minimums. In the Seattle Justice Center, combined improved chiller performance, a hydronic heating distribution system, and heat pumps are utilized to increase energy performance. In the City Hall, an under-floor HVAC system, variable speed pumping, efficient chillers, variable frequency drives, and demand ventilation have been installed increase energy efficiency.

Energy-Efficient Lighting

Lighting is typically the most power-consuming component in a building's energy budget. Reducing lighting energy demand through daylighting and efficient fixtures can have significant impact on the total energy consumption of a building.

Energy Use in Commercial Buildings

- Space Heating 22%
- Space Cooling 23%
- Office Equipment 11%
- Other 6%
- Water Heating 7%
- Lighting 31%
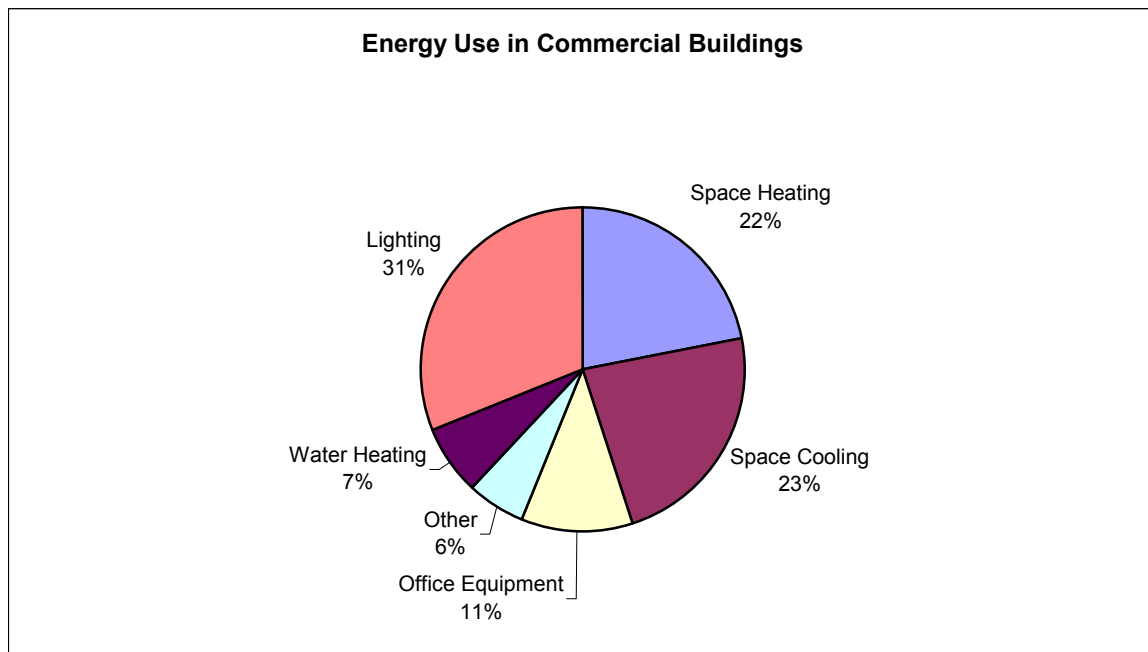
Lighting Controls

In typical office buildings the lighting is often left on when a room is empty, or when daylight could provide necessary lighting instead. Occupant sensors, daylight sensors and appropriate zoning enable lights to be turned off when they are not needed. Occupancy sensors are used in the City Hall while wall switch timers and daylighting sensors are used in the Seattle Justice Center.

Raised Floor

A raised floor with an underfloor air distribution system was installed in the northern office tower portion of the City Hall that is used as a plenum space for ventilation for supply air. This technique supplies air closer to occupants and allows for warmer cooling supply air than typical ceiling mounted diffusers. The result is a more efficient HVAC distribution system that has reduced demand for cooling while maintaining appropriate occupant thermal comfort.

Commissioning

Commissioning is a pre- and post-construction service that ensures that all equipment (HVAC, lighting and other mechanical equipment) installed is operating according to designed standards. Often what appear to be minor oversights, such as set temperature being a few degrees too high or too low, can have significant cost implications of energy savings for the entire year. Energy Economics Inc. performed commissioning on the Seattle Justice Center. In their Energy Impact Summary report, annual energy savings in kilowatts per hour (kW/H) were estimated for each adjustment and translated into annual energy cost savings. They will also complete commissioning on City Hall in 2004.

Indicator Methodology

The City of Seattle Office of Sustainability and Environment (OSE) has been tracking electricity consumption in existing City buildings since 1997. For this evaluation plan the new buildings will require a building-specific baseline, using a model of the buildings designed to meet Seattle Energy Code.

The main goal is to verify actual energy savings against baseline calculations. Prior to construction, baseline energy models were produced that included predictions of weather data, energy prices and occupant loads. This evaluation will seek to verify the accuracy of these predictions and generate a new and on-going baseline and data collection methodology. This will require that baseline predictions be revised to reflect as-built conditions as accurately as possible.

A specific Measurement and Verification (M&V) Plan has been developed for each building as described in Section 4. The goal of the M&V plan will be to identify specific building energy performance characteristics in a format that will provide on-going verification of anticipated energy savings and consumption, and will provide feedback to building operators on system performance.

The basic strategy for M&V will include the following steps:

Step 1: Establish predicted baseline: Refine model based on as-built conditions.

Step 2: Revise predicted baseline to reflect actual conditions: Adjust the model with actual weather, occupancy and other data.

Step 3: Collect building performance data: Refer to the M&V Plan in Section 4 for methods.

Step 4: Comparison and analysis: Compare actual consumption to predictions, to evaluate performance and to direct maintenance efforts if required.

In this way, evaluation efforts will focus on the most critical aspects of building energy performance; providing information for the achievement of energy efficiency and providing on-going feedback to building operators on system performance. The results of the report may identify more specific and in-depth evaluations that would help to characterize building energy performance characteristics further.

Data Collection Table

Seattle Justice Center Energy Impact Summary for Commissioning*			
Equipment	**Action Performed**	**Estimated Savings**	
		kW/H	**$ ($0.0632/kWh)**
AHU-6	Adjust exhaust damper	-	$0.00
AHU- 3,4,5,6,&7	Calibrate temperature sensors	4,715	$297.96
VFD	None	-	$0.00
All AHUs	Adjust outside air sensors	7,444	$464.00
VAV Boxes	Adjusted comfort range	62,458	$3,891.00
TU-11-28	Adjust hot water valve heating	1,942	$121.00
Chillers	Economizer adjustment	211,765	$13,192.96
	Totals	288324	$17,966.92

*Data taken from Final Commissioning Report by Engineering Economics, Inc.

#5	Emissions Associated with Energy Use	Environment
		Social Equity
		Economics

Indicator Information

Data Coordinator:	Seattle City Light	**Start Measurements:**	2004
Contact Person:	Jack Brautigan	**End Measurements:**	2005
Baseline:	Seattle Code Building	**Review Data:**	Quarterly
Supplemental Data:	Corinne Grande, SCL	**LEED Credits:**	Energy & Atmosphere Credit 1

Schedule

Indicator Description

The Indicator is a measure of environmental impact associated with energy generation.

In Seattle, electricity is provided from multiple sources, with varying degrees of CO_2 emissions. Currently, Seattle City Light's (SCL) energy product is a mix of sources, per the breakdown below.

Hydro-electric: 90.2%

Coal and natural gas: 5.9%

Wind: 1.1&

Biomass: 0.1%

Waste incineration: 0.2%

Nuclear: 2.6%

SCL purchases emissions mitigation for electricity procured from coal, natural gas, nuclear and incineration. When buildings save energy, the overall energy demand of the utility is reduced, as is the need for emissions mitigation. The utility adds emission-producing sources to the mix only as overall demand exceeds the capacity of hydroelectric and wind sources. As energy demand is reduced, the sources with higher emissions are removed first. This indicator looks at the tons of CO_2 avoided due to energy savings described in Indicator 4.

Indicator Methodology

By tracking total energy saved, the environmental impacts of reduced energy production can be calculated. An externality adder is applied to the "new" amount of electricity produced to meet increased demand, over that which can be supplied by hydro and other low-emitting sources. The emissions adder therefore is not a value that applies to the average MWh in the current SCL portfolio. The resource mix that will be brought on to meet new demand will change over the next 20 years. Thus an estimate of what the mix is in 2003 and will be in 2023 was made and then extrapolated for

the intervening years. SCL currently sets the emissions factor at 0.545 tons per MWh of electricity per EPA Region 10 data. By 2023, the emissions factor may be down to 0.461 tons per MWh of electricity, based on SCL assumption that new generation sources would likely be from combined cycle gas turbine generators (90%), with a small amount of coal (10%); these would be the first sources to be eliminated due to reduced energy loads.

Data Collection Table

Emissions Forecast Table*		
Emission Factors:	**Year 2003**	**Year 2023**
Mix	EPA Region 10	90% Combined Cycle CT 10% Coal
Factor (tons CO2/MWh)	0.545	0.461

Year	$/ton CO2**	Emission Factor*** (tons/mWh)	Externality Adder ($/MWh - for CO2)
2003	$40.00	0.55	$21.81
2004	$40.00	0.54	$21.64
2005	$40.00	0.54	$21.47
2006	$40.00	0.53	$21.31
2007	$40.00	0.53	$21.14
2008	$40.00	0.52	$20.97
2009	$40.00	0.52	$20.80
2010	$40.00	0.52	$20.63
2011	$40.00	0.51	$20.47
2012	$40.00	0.51	$20.30
2013	$40.00	0.50	$20.13
2014	$40.00	0.50	$19.96
2015	$40.00	0.50	$19.80
2016	$40.00	0.49	$19.63
2017	$40.00	0.49	$19.46
2018	$40.00	0.48	$19.29
2019	$40.00	0.48	$19.12
2020	$40.00	0.47	$18.96
2021	$40.00	0.47	$18.79
2022	$40.00	0.47	$18.62
2023	$40.00	0.46	$18.45

* Data Souce: Seattle City Light, Science Policy Unit, September, 2003.

** $40 per ton is used as an estimate of the externality cost of CO2 emissions. It is higher than the current 2003 market price for CO2 mitigation projects, but significantly lower than the estimates of auction prices that might be required to bring CO2 emissions to Kyoto levels.

*** Emission factors for years 2004 - 2022 are based on straight-line decline from 2003 to 2023 level.

#6	**Construction Demolition & Land-Clearing Waste**	**Environment**
		Social Equity
		Economics

Indicator Information   Schedule

Data Coordinator:	Seattle Public Utilities	**Start Measurements:**	2001
Contact Person:	Lucia Athens	**End Measurements:**	2004 (Thru Completion of City Hall Plaza)
Baseline:	Landfill	**Review Data:**	End of Construction at time of LEED Submittal
Supplemental Data:	LEED Applications Hoffman Contracting	**LEED Credits:**	Materials & Resources Credit 2

Indicator Description

The Indicator is a measure of the solid waste diverted from the municipal waste stream going to conventional landfills.

During construction, contractors at both the Seattle Justice Center and the City Hall projects implemented construction waste management plans as specified by the architects. A comprehensive construction waste management plan can greatly reduce the amount of materials sent to rapidly overburdened landfills and can also save money for the project. The amount of materials that were recycled, re-used or sent to salvage facilities will be measured.

Indicator Methodology

Since both projects incorporated construction waste management plans as part of their pursuit of LEED Silver Ratings, the contractors were required to collect tipping receipts from their waste haulers. As part of the LEED Application, total waste and total recycled, reused or salvaged material volumes were tracked. The LEED Applications are still in progress; final results will be available in 2004.

		Environment
#7	**Recycled Content Materials Used**	Social Equity
		Economics

Indicator Information

Data Coordinator:	Seattle Public Utilities	**Start Measurements:**	2001
Contact Person:	Lucia Athens	**End Measurements:**	2004 (Thru Completion of City Hall Plaza)
Baseline:	Virgin Materials	**Review Data:**	End of Construction at time of LEED Submittal
Supplemental Data:	LEED Calculators	**LEED Credits:**	Materials & Resources Credit 4

Schedule

Indicator Description

The Indicator is a measure of the market demand signal for recycled content building products that is sent by City of Seattle construction activity.

Certain materials that were used in the Seattle Justice Center and the City Hall projects included an amount of recycled content. By using recycled materials, the demand for virgin materials is reduced and the demand for recycled materials is increased that aids in market transformation.

Indicator Methodology

The LEED Application documentation methodology will be used to track the dollar value of recycled content materials used in the two buildings.

In addition, the LEED Application for this credit should include cut sheets of each recycled content material. Therefore, if sufficient funding and interest are present, some recycled materials calculations by weight could be performed. While a dollar value of materials may be used as an indicator of market transformation or the worth of recycling materials, the weight of these materials is an indicator of avoided landfill burden. However, that is not specific to Seattle landfills, since recycled materials are likely to come from various locations throughout the country.

		Environment
#8	**Indoor Air Quality**	Social Equity
		Economics

Indicator Information

Data Coordinator:	Safety Office	
Contact Person:	Bill Budd	
Baseline:	Conventional Buildings	
Supplemental Data:	Air quality measures at Public Safety Building and Municipal Building.	

Schedule

Start Measurements:	Summer 2003
End Measurements:	On-going
Review Data:	On-going
LEED Credits:	Environmental Quality Credits 1, 2, & 4

Indicator Description

The Indicator is a measure of the amount of CO_2, CO, particulate concentration and particulate matter in the air. There will also be spot measurements of VOCs and aldehydes in location of air quality concerns.

Office workers spend over 80% of their lives indoors. Conventional construction results in interiors full of synthetic materials that off-gas chemicals into the air. Conventional construction practices can also result in construction dust and VOCs in the finished building. Both the City Hall and Justice Center have installed low-emitting adhesives, paints, and carpets. Indoor air quality planning during the construction of both buildings was also designed to protect ductwork to prevent dust contamination and to install materials in proper sequence to minimize absorption of VOCs by permeable materials such as carpeting and fabric. An example of this is to install carpet after the paint has dried completely. Reduced emissions and particulates are therefore indicators of indoor air quality, and complement the data collected under Indicators 15 and 16 regarding Perceived Worker Effectiveness and Workplace Satisfaction.

Shelley Reese's study, " The Hidden Cost of Allergies," suggests that average missed days of work due to allergies and asthma to be 3.3 and 3.4 days per year respectively. Building related sick leave can have a significant impact on a company's or organizations annual productivity. A study by building science researcher William Fisk highlights the significance of good indoor air quality. His study, "Health and Productivity Gains from Better Indoor Energy Efficiency", shows indirect costs associated with asthma, allergies, and other airway associated diseases as $5.2 billion annually in the U.S. The studies also revealed that symptoms can be reduced by 8-25% with indoor quality design strategies.

Indicator Methodology

Measurements of CO2, CO, particulate concentration and particulate matter in the air of the two buildings will be compared to the data for new and recent buildings with conventional materials and ventilation practices. An ideal baseline would be sampling of other new, but conventional, buildings in the Seattle area. However, to work within the planned budget, the Safety Office may work with the University of Washington to research other studies that may have baseline sampling data for either the northwest region or national buildings.

Volatile Organic Compounds (VOCs)

Both the Justice Center and City Hall have been designed with low-emitting materials, which will have a positive impact on indoor air quality. However, due to the expense of the testing, the Safety Office will measure VOCs and aldehydes only in areas where there are concerns about the indoor air quality.

Particulates

The particulate that will be measured includes: PM10 and Ultra Fine Particulate as well as spot samples to characterize the particulate by light microscopy. PM10 is a mass measurement (i.e., micrograms per cubic meter) of the particles whose aerodynamic diameter is smaller than 10 microns or 10E-5 meters. The Ultra Fine particulate is a particle count concentration (i.e., particles per cubic centimeter) and is here operationally defined as those particles that are counted by the TSI P-Trak. The nominal particle size sampling range for the P-Trak is 0.02 microns to 1 micron.

Data Collection Table

Data Point	Equipment	Measurement Location	Collection Lead
CO2 Concentration	TSI Q-Trak	Representative Spaces on Each Floor	Safety Office
CO Concentration	TSI Q-Trak	Representative Spaces on Each Floor	Safety Office
PM 10 Particulates	TSI Dust Trak	Major Areas/Spaces	Safety Office
Ultra-fine Particulates	TSI P-Trak	Major Areas/Spaces	Safety Office
Relative Humidity	TSI Q-Trak	Each Floor	Safety Office
Air Temperature	TSI Q-Trak	Each Floor/Major Area	Safety Office
VOCs	Lab (Charcoal, GC-FID)	Complaint Areas	Safety Office
Aldehydes	Lab (DNPH, LC Analysis)	Complaint Areas	Safety Office
Baseline	NA	NA	University of Washington Industrial Hygiene Department

		Environment
#9	**Comfort Complaints per Year**	**Social Equity**
		Economics

Indicator Information

Schedule

Data Coordinator:	Safety Office	**Start Measurements:**	Summer 2003
Contact Person:	Air Quality: Bill Budd	**End Measurements:**	On-going
	Thermal: Jackie Campbell and Joe Garcia		
Baseline:	HR Data / FFD Data	**Review Data:**	On-going
Supplemental Data:	Service call tracking	**LEED Credits:**	Environmental Quality Credits 1, 2, & 4

Indicator Description

The Indicator is a measure of worker satisfaction with their working environment and the active building systems.

There are many sources of comfort complaints that affect an employee's productivity. Spaces that are too hot or cold, that have inadequate ventilation or lighting, or too much lighting or glare, can significantly impact a person's ability to perform tasks. Overhead costs associated with comfort complaints include: loss of task productivity, staff time complaining, staff time responding, and cost to fix the problem. Reducing or eliminating comfort complaints through proper ventilation, temperature control and illumination can result in increased productivity. By tracking the number of comfort complaints, the actual increase in productivity can be estimated based on the average amount of time spent responding to the problem (refer to indicators #10 & #11 for the overhead coasts associated with comfort complaints.).

While IAQ complaints often are minor in nature, there have been situations they have caused major disruption to the business operation. For example, in 1997 the previous 911 Communication Center was evacuated due to worker concerns about their health. This was preceded by complaints about air quality and/or working conditions. In the case of the 911 Communication Center, some of the parking garage air was pulled into the outdoor supply air for the 911 Center and the air itself often had low relative humidity. There was also concern about sewer gas odors and solvent smell in areas adjacent to the 911 Center and dust levels in the 911 Center itself. The old 911 Center was in the center of the building with no windows, which may have contributed to a sense of lack of control in the employees who also had to stay at their workstation to receive calls. This, coupled with other working conditions, probably contributed to the dissatisfaction and complaints. Such incidents of building-related IAQ complaints carry a considerable cost burden to the City.

Indicator Methodology

Comfort complaints will be monitored through the HR department and compared to previous data. Data for the new buildings will commence once commissioning has been completed and initial adjustments following building occupancy have been made.

Since every complaint is not recorded or even reported, it is not a true measure of comfort. Complaints really measure workplace dissatisfaction and are not a true indicator of workplace satisfaction. The Judith Heerwagen and Associates pre- and post-occupancy survey address this issue by recording the level of workplace satisfaction that is attained through improved working environments.

There are many factors that affect employee turnover rates which are not quantifiable, such as changes in workers' personal lives, in their tasks, or in the organization. Personnel and management changes can also affect an employee's ability to perform. In some cases, the information is too personal; employees may be hesitant to disclose details. In other cases, data is unavailable. For example, there is no record of management changes linked to complaint periods at the buildings these employees occupied previously, the Municipal Building and the Public Safety Building. However, for the purposes of this indicator, these factors are assumed to be equal from the older buildings to the newer Justice Center and the City Hall Building.

		Environment
#10	**Absenteeism Rates**	**Social Equity**
		Economics

Indicator Information

Data Coordinator:	Personnel	**Start Measurements:**	Summer 2003
Contact Person:	Sharon Tanberg Mickelson	**End Measurements:**	On-going
Baseline:	HR Data (Since 11/1995)	**Review Data:**	Annually
Supplemental Data:	Personnel Records Unit Safety & Workers' Comp Data	**LEED Credits:**	All Environmental Quality Credits

Schedule

Indicator Description

The Indicator is a measure of the general health of the worker population.

A reasonable indicator of the triple bottom line is that of absenteeism. Workers that have fewer issues with work strain (eye strain, thermal strain, respiratory strain, etc.) are more likely to have fewer absent days. Clean air, proper illumination, proper ventilation, and low VOC materials make environments healthier and more pleasant to work in. The result is not only an increase in overall workplace satisfaction but also reduces absenteeism.

The amount of sick time, time loss from workers' compensation claims, and other time excluding paid vacation or executive leave time taken by employees has significant impact on productivity and the triple bottom line. Overhead costs associated with absenteeism include: paid time off, loss of productivity, and increased health care insurance rates.

William Fisk's study, Health and Productivity Gains from Better Indoor Energy Efficiency, suggests a 35% lower absence rate in buildings with high ventilation (>24 liters/second/person) and a 9-20% decrease in occurrences of respiratory illness with improved ventilation and air quality. Results for this indicator are therefore related to those under Indicator #8 Indoor Air Quality.

Indicator Methodology

Absenteeism will be monitored through the Personnel Department (Personnel Records Unit and Safety & Workers' Comp Units) and compared to previous data. Absenteeism and sick leave will be tracked by department, and not on an individual employee basis. According to Julie Curtis in the Personnel Department the average number of sick and time loss days taken by employees before moving into the Seattle Justice Center or the City Hall was 6-8 days per person per year.

There are many factors that affect employee turnover rates which are not quantifiable, such as changes in workers' personal lives, in their tasks, or in the organization. Personnel and management changes can also affect an employee's ability to perform. However, for the purposes of this indicator, these factors are assumed to be equally present the older buildings and the new Justice Center and the City Hall Building.

		Environment
#11	**Employee Turnover Rates**	**Social Equity**
		Economics

Indicator Information   Schedule

Data Coordinator:	Personnel	**Start Measurements:**	Summer 2003
Contact Person:	Sharon Tanberg Mickelson	**End Measurements:**	On-going
Baseline:	HR Data (Since 11/1995)	**Review Data:**	Annually
Supplemental Data:	Personnel Records Unit	**LEED Credits**	All Environmental Quality Credits

Indicator Description

The Indicator is a composite measure of worker satisfaction with site conditions, job duties and external opportunities for career enhancement.

Employee turnover has significant impact upon an organization's ability to be productive and thus the triple bottom line. The U.S. Department of Labor estimates the average cost of turnover to be 33% of an individual's salary. Employees that are happy and healthy, and thus productive, are less likely to be leave or be terminated. The average time a city position stayed vacant was 112 workdays in 2001. The overhead costs associated with high turnover rates include: loss of productivity, staff time reorganizing, the staff time associated with the search for qualified candidates, training new employees and increased managerial loads.

Building features addressed by other Indicators in this study such as daylighting and indoor air quality can contribute to a healthier and more pleasing work environment and can positively impact employee satisfaction and retention. When employee turnover occurs, others must absorb the workload and adjust work patterns that affect an organization's productivity. Conversely, an organization can benefit by retaining productive employees for as long as possible.

Indicator Methodology

Employee turnover rates will be monitored through the Personnel Records Unit department and compared to previous data. Data compiled from 2000 to mid 2003 for departments that were relocated into the City Hall and the Justice Center will be used as the baseline.

There are many factors that affect employee turnover rates which are not quantifiable, such as changes in workers' personal lives, in their tasks, or in the organization. Personnel and management changes can also affect an employee's ability to perform. However, for the purposes of this indicator, these factors are assumed to be equally present in the older buildings and the new Justice Center and the City hall.

Data Collection Table

Employee Turnover Data					
Department	**2000**	**2001**	**2002**	**2003**	**Total**
Finance	1	3	3		**7**
Fleets and Facilities	11	15	9	4	**39**
Law Department	29	19	19	2	**69**
Legislative	14	39	8	1	**62**
Municipal Court	33	47	47	14	**141**
Neighborhoods Department	4	6	14		**24**
Police Department	78	65	84	3	**230**
Integovernmental Relations	1	1	3		**5**
Termination Total	171	195	187	24	**577**

* Data does not include Office of Policy and Management, currently unavailable.

** Data includes only employees that left voluntarily, and not retirees or those who were terminated for cause.

Employee Turnover Data by Action Code					
Department Name	**Action**	**Action Reason**	**2000**	**2001**	**2002**
Integovernmental Relations	Termination	RES	1	1	2
		XMT			1
Law Department	Termination	ESP			2
		EXP		1	
		RES	19	17	14
		TFL		1	
		TMP	10		1
		XMT			2
Legislative	Termination	ESP			1
		RES	7	9	7
		TMP	6	30	
		XMT	1		
Municipal Court	Termination	ESP			7
		LVE			1
		QUT	1	3	1
		RES	30	22	17
		TMP	1	22	20
		XHR	1		1
Neighborhoods Department	Termination	RES	4	6	13
		XMT			1
Police Department	Termination	ESP			9
		LVE		1	
		QUT			1
		RES	76	60	68
		TFL		1	1
		TMP	1	2	5
		XHR	1	1	
Grand Total			**159**	**177**	**175**

REASON CODE	REASON DESCRIPTION	DESCRIPTION OF USE FOR ACTIONS AND REASON CODES
Included in Evaluation		
DSP	Discharge - Probationary	Use to show a probationary employee is terminated for cause.
LVE	Failure to Return from Leave	Use to show an employee is terminated for failure to return from a leave of absence.
PTD	Partial/Total Disability	Use to show an employee is terminated due to a partial or full disability.
QUT	Quit	Use to show an employee is voluntarily separating without a written resignation or the employee did not fullfill the required 2 weeks notice.
RES	Resignation	Use to show an employee is voluntarily separating and has a signed written resignation statement 2 weeks prior to his/her last day of work.
XMT	Separation of Exempt Employee	Use to show an exempt employee being separated by the appointing authority.
Not Included in Evaluation		
DEA	Death	Use to show an employee is separated due to death.
DSN	Discharge - Non-Probationary	Use to show a temporary, exempt or regular employee is terminated for cause.
ESP	(Resignation) Early Separation Incentive Program	Use to show an employee is terminating due to accepting the Separation Incentive Program, Resignation
EXP	Expiration of Term of Office	Use to show an employee's term of office has expired. This code is used for elected officials.
TFL	Not reinstated from one year layoff	Use to show an employee being terminated for not being reinstated within one year from layoff status after a non-disciplinary suspension.
TMP	Temp Empl Not Worked One Year	Use to show a temporary employee has not worked in the previous 12 months (one calendar year) or 26 pay periods (per Local 17 or Joint Crafts contracts) per the temporary settlement agreement.
XHR	Cancel Hire	Use to show a new hire employee accepted a job offer and appointment entered into CSS but never reported for work.

		Environment
#12	**Access to Daylight**	**Social Equity**
		Economics

Indicator Information

Data Coordinator:	Daylighting Design Lab
Contact Person:	Chris Meek
Baseline:	Municipal Bldg.
Supplemental Data:	Daylight Measurements

Schedule

Start Measurements:	June 2003
End Measurements:	November 2003
Review Data:	1st Quarter 2004
LEED Credits:	Environmental Quality Credit 8

Indicator Description

The Indicator is a measure of how connected workers are to the outdoors.

Natural daylighting improves the indoor environment by exposing occupants to natural light. Daylighting and access to views provide a connection to the outdoors, creating a sense of place within the buildings. An abundance of natural light decreases energy costs by eliminating the demand for artificial lighting. A well-designed building layout will maximize access to daylight, and can reduce lighting energy use between 50-80% if lights can be switched off or dimmed when sufficient daylight is present. Using less energy conserves natural resources and reduces the impacts due to energy production and consumption. Daylit spaces also foster occupant and employee satisfaction, reducing absenteeism and illness.

Daylighting is measured as a percentage of space with access to daylight. Areas such as offices, meeting areas, courts and council chambers, which are regularly occupied, are included within the measurements. Areas not considered are circulations spaces, storage, and restrooms.

Indicator Methodology

The BetterBricks Daylighting Design Lab Seattle performed a pre-demolition evaluation of the visual environment of the Seattle Municipal Building and the evaluation for the new Seattle City Hall is underway for comparison. This data will be used as a baseline. Paladino assisted in data collection and occupant mapping calculations with the information provided from the Daylighting Design Lab and the design teams' LEED calculations. The Seattle Justice Center evaluation has already been completed by the DDL in the summer of 2003. Refer to Appendix A for the Municipal Building, Justice Center, and the City Hall reports on daylighting by the DDL.

Testing of the daylighting performance of the Municipal Building was complicated by several factors related to the construction of the new City Hall. First was the presence of gypsum wallboard covering 90% of the glazing on the building's east façade. Secondly, the occupants were in the midst of relocating to their new office space, and much of the interior office equipment, partitions, task

lighting, etc. was removed or packed in boxes. This prevented documentation of "natural" use patterns and user initiated sun control configurations.

A 3/8" = 1'-0" physical scale model built by Paladino and the Daylighting Lab's heliodon sun simulator were used to evaluate direct sun conditions through the calendar year. Also, testing was performed with the physical model in the Daylighting Lab's mirror-box overcast sky simulator to evaluate a typical open office floor of the Municipal Building without the east glazing obscured.

The scope of testing included three representative spaces. First was the third floor open office area(s) with interior office partitions in place (this was the only floor where partitions remained in place). Second was the seventh floor open office area(s) without interior office furniture. Third was an investigation of typical hard-wall offices on the tenth floor.

Currently, the daylight conditions along the west façade differ from design intentions, since the Municipal Building has not yet been demolished. The demolition is planned to be complete by the end of 2003. The Daylighting Design Lab will return to take measurements in February or March of 2004 which will allow sufficient time to fine tune the lighting and controls systems in the City Hall building in its final configuration, with an open plaza to the west of the building.

Data Collection Table

Data Analysis	Measurement Lead	Equipment	Frequency
Justice Center: Daylight Distribution	The Center for the Built Environment	Illuminance Meters (light meters)	Different times of year, times of day and weather conditions
	Daylighting Design Lab	Light Meter	Completed in 2003
Municipal Building: Daylight Distribution	Daylighting Design Lab	Light meters, scale model, and heliodon	One time study
City Hall: Daylight Distribution	Daylighting Design Lab	Light Meter	Select days Fall 2003-Spring 2004 for light measurements
	Judith Heerwagen and Associates	Online survey	One-time study for survey
Justice Center: LEED Daylighting Calculations	NBBJ Architects	N/A	N/A
City Hall: LEED Daylighting Calculations	Bassetti Architects/Bohlin Cywinski Jackson	N/A	N/A

		Environment
#13	**Visual Comfort Conditions**	**Social Equity**
		Economics

Indicator Information

Data Coordinator:	Paladino & Co., Inc.
Contact Person:	Teresa Burrelsman
Baseline:	Municipal Bldg.
Supplemental Data:	JH & Associates Survey
	DDL Measurements
	CBE Measurements

Schedule

Start Measurements:	April 2003
End Measurements:	Ongoing
Review Data:	1st Quarter 2004
LEED Credits:	Environmental Quality Credit 8

Indicator Description

The Indicator is a measure of lighting environment suitability to the visual tasks that must be performed.

The quality of visual comfort will have significant impacts on an employee's ability to perform tasks in a productive manner. There are a number of factors that affect visual comfort conditions. If a space is over or under-illuminated, visual strain can negatively impact productivity. Glare, or brightness ratio, is the measure of dark to bright surfaces. Ratios that exceed task-orientated recommendations cause visual discomfort due to the eye's inability to quickly adjust to abrupt changes in light and darkness thus negatively impacting productivity. In addition, spaces designed with uniform lighting cause visual strain due to one's inability to judge distance and induce a feeling of spatial monotony. A design that introduces varying light levels within brightness ratios, natural daylight and lighting that is task orientated will improve worker satisfaction and productivity.

Indicator Methodology

Glare, view and daylight measurements will be compared from pre-occupancy and post-occupancy conditions in the City Hall Building. A post-occupancy evaluation has been completed for the Seattle Justice Center, but no pre-occupancy was collected prior to the move. The BetterBricks Daylighting Design Lab Seattle (DDL) will perform measurements with data collection assistance from Paladino and Company. The DDL will evaluate comfort, creating a recommendation report for daylighting measures to increase comfort. The Center for the Built Environment (CBE) will provide fisheye lens photos as well as handheld illuminance meter readings to assess visual comfort. Judith Heerwagen and Associates will conduct a survey of conditions and perceptions of employees for pre and post occupancy at the City Hall. The CBE study, conducted by Robert Marcial, is performed on the Justice Center, but focuses on the thermal buffer wall. Included is a survey that asks are some similar

questions as the post occupancy survey performed by Judith Heerwagen and Associates. The CBE study will focus on the areas adjacent to and along the perimeter of the thermal buffer wall.

Data Collection Table

Data Analysis	Measurement Lead	Equipment	Frequency/Schedule
Justice Center **Visual Comfort**	Center for the Built Environment	Luminance Meters (brightness meters), Fisheye Photos	Seasonal Summer 2003-2004, varied times and weather conditions
Luminance	Daylighting Design Lab	Light Meter	Completed in 2003
Municipal Building **Visual Comfort** **(Perceptions)**	Judith Heerwagen & Associates	Online Survey	Completed in 2003
Visual Comfort **(Measurements)**	Daylighting Design Lab	Light meter, scale model, and heliodon	Completed in 2003
Luminance	Daylighting Design Lab	Light Meter	Completed in 2003
City Hall **Visual Comfort** **(Perceptions)**	Judith Heerwagen & Associates	Online Survey	First Quarter 2004
Visual Comfort **(Measurements)**	Daylighting Design Lab	Light meter, scale model, and heliodon	Completed in 2003
Luminance	Daylighting Design Lab	Light Meter	Completed in 2003

		Environment
#14	**Thermal Comfort Conditions**	**Social Equity**
		Economics

Indicator Information

Schedule

Data Coordinator:	Paladino & Co., Inc.	**Start Measurements:**	April 2003
Contact Person:	Teresa Burrelsman	**End Measurements:**	2004
Baseline:	Conventional Glazing/Wall	**Review Data:**	Quarterly/Varies
Supplemental Data:	Center for the Built Environment Thermal Comfort Measurements – Justice Center only	**LEED Credits:**	Environmental Quality Credit 7
	JH & Associates Survey performed on the City Hall		
	Bill Budd from the Safety Office – air temperature		

Indicator Description

The indicator is a measure of how closely the building active systems can maintain conditions that are reported to be comfortable by the occupants.

Thermal comfort is related to air temperature and velocity, drafts and exposure to cold or hot surfaces. Increased thermal comfort for employees generally increases their attentiveness, effectiveness and their feeling of well-being. This can result in indirect benefits to employers, such as reduced overhead costs associated with comfort complaints, absenteeism, and employee turnover. One of the key design features of the Justice Center is the thermal buffer wall which covers approximately 75% of the west wall. One of the reasons the thermal buffer wall was incorporated into the design was to increase thermal comfort. The double walls of glass, separated by a 24" air space, will insulate the interior surface of the glass from the more extreme outdoor air temperatures. This is expected to result in an interior surface with a temperature closer to that of ambient indoor air. Without the cold or heat radiating from the interior surface of the glass, employees stationed near the exterior should experience higher comfort levels.

Indicator Methodology

The Center for the Built Environment has placed temperature and air flow sensors inside the thermal buffer wall. They have placed anemometers at two locations or each of four floor levels to measure air temperature and airflows. Temperature loggers will record air temperatures. These measurements will be used to determine the volume of air exhausted at the top of the wall, its temperature, and the thermal stratification patterns within the wall.

The CBE designed and built Indoor Comfort Assessment Modules (ICAMs) especially for this project, to measure interior thermal comfort variables. To provide a baseline comparison, ICAMs will be placed at workstations adjacent to both the thermal buffer wall and the conventional wall. The ICAMs consist of four sensors: air velocity, ambient air temperature, globe temperature facing the windows, and globe temperature facing the interior area.

In addition to the building measurements, the CBE has also conducted an occupant survey. Randomly selected occupants adjacent to either the thermal buffer wall or the conventional west-facing wall were queried about their workplace environment, level of control and perceptions of thermal comfort. The survey results, in conjunction with the building measurements, will provide a picture of the comfort conditions within the Justice Center. Comfort will be reported based on the percentage of employees near each wall condition who report feeling comfortable. This will be correlated with the performance measurements taken within the buffer wall. The data collected in 2003-04 in the City Hall will be compared against data from the pre-occupancy study collected from the old municipal building. Data for the Justice Center will be post-occupancy only. The data will also be used to refine the building energy model used in the Measurement and Verification Plan in conjunction with Indicator 4 Energy Use.

Data Collection Table

Data Analysis	Measurement Lead	Equipment	Frequency
Justice Center **Thermal Buffer Performance**	Center for the Built Environment	Anemometers, Temp. Loggers	Continuous
Indoor Thermal Comfort	Center for the Built Environment	ICAM loggers (air velocity, ambient temp., globe temp.)	Continuous
Occupant Survey	Center for the Built Environment	Web Based Survey Form	4-6 times for three days per occupant
Direct Solar Access	Center for the Built Environment	Fisheye and Orthographic Projections	Seasonal
Air Temperature Measurements	City of Seattle Safety Office	Temperature sensor	Ongoing
Municipal Building **Occupancy Survey**	Judith Heerwagen & Associates	Online survey	1 Time
City Hall **Occupancy Survey**	Judith Heerwagen & Associates	Online survey	1 Time
Air Temperature Measurements	City of Seattle Safety Office	Temperature sensor	Ongoing

		Environment
#15	**Perceived Worker Effectiveness**	**Social Equity**
		Economics

Indicator Information

Data Coordinator:	Fleets & Facilities Division	**Start Measurements:**	April 2003
Contact Person:	Amanda Sturgeon	**End Measurements:**	2004
Baseline:	None	**Review Data:**	Spring & Fall, 2004
Supplemental Data:	Judith Heerwagen Associates City Hall Survey	**LEED Credits:**	All Environmental Quality Credits
	Center for the Built Environment Justice Center Survey		

Schedule

Indicator Description

The Indicator is a measure of general worker satisfaction with the conditions of their workplace.

Worker effectiveness will be evaluated through occupant surveys of employees working in the new City Hall and Justice Center. The term 'perceived' worker effectiveness is used to represent the fact that the survey asks for employees perceptions with respect to how the building affects their performance. Actual worker effectiveness can be measured for some work tasks, such as manufacturing performance or repetitive task performance. Measurement is more difficult, however, in the case of knowledge workers. For the types of work associated with city staff in office spaces, worker effectiveness addresses productivity, increased attentiveness, decreased absenteeism, and increased employee retention.

Indicator Methodology

Occupant surveys provide a valuable source of information, gauging the effectiveness of high performance buildings and new or innovative strategies. With the City's adoption of LEED and sustainable building, it is critical to determine which design features work well and which don't, and to use that information for future projects and for education of the private sector.

A retrospective pre-occupancy survey, conducted after the move to the City Hall, queried the occupants on their perceptions of their former office space in the Municipal Building. A post-occupancy survey, conducted separately, will ask occupants to rate their new space. Questions address thermal comfort, daylighting and perceptions of whether or not the space affected their job in either a positive or negative way.

Judith Heerwagen Associates will administer all surveys online for the City Hall workers, using a questionnaire developed by the Center for the Built Environment at the University of California, Berkeley.

A survey of a subset of Justice Center occupants along the west perimeter wall was conducted by the Center for the Built Environment (CBE). The main purpose of this survey is to query occupants about thermal and visual comfort related to CBE's thermal performance study of the double skin wall. However, that data will also be used for evaluation of Indicator 15.

		Environment
#16	**Workplace Satisfaction**	**Social Equity**
		Economics

Indicator Information

Schedule

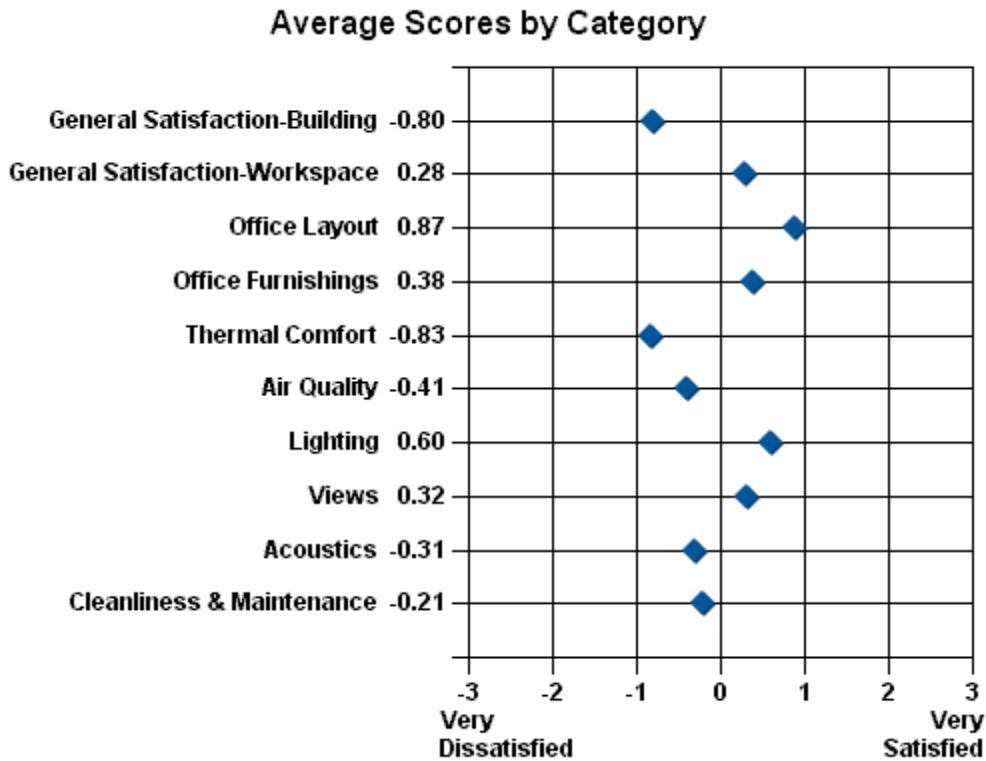|			
Data Coordinator:	Fleets & Facilities Division	**Start Measurements:**	April 2003
Contact Person:	Amanda Sturgeon	**End Measurements:**	2004
Baseline:	Pre-occupancy conditions	**Review Data:**	Spring & Fall 2004
Supplemental Data:	Judith Heerwagen Associates City Hall Survey	**LEED Credits:**	Indoor Environmental Quality Credits 6, 7 & 8
	Center for the Built Environment Justice Center Survey		

Indicator Description

The Indicator is a measure of general worker satisfaction with the physical surroundings in which they work.

Workplace Satisfaction will be evaluated through occupant surveys of employees working in the new City Hall and Justice Center. Workplace satisfaction has implied connections with absenteeism and employee turnover. The benefit may be realized in reduced Personnel Department overhead, reduced searching for and hiring new employees, or in reduced time spent by the Safety Office or Fleets and Facilities in responding to comfort complaints.

Indicator Methodology

A pre-occupancy survey, conducted after the move to the new building, queried the occupants on their perceptions of their former office space. A post-occupancy survey, to be conducted separately, will ask occupants to rate their satisfaction of the new space. Questions addressed thermal comfort, daylighting and perceptions of whether or not the space affected their workplace satisfaction in either a positive or negative way.

Data Collection Table

Average Scores by Category

Category	Score
General Satisfaction-Building	-0.80
General Satisfaction-Workspace	0.28
Office Layout	0.87
Office Furnishings	0.38
Thermal Comfort	-0.83
Air Quality	-0.41
Lighting	0.60
Views	0.32
Acoustics	-0.31
Cleanliness & Maintenance	-0.21

Scale: -3 Very Dissatisfied to 3 Very Satisfied

Graph: Results of Municipal Building Occupancy Survey Regarding Workplace Satisfaction

		Environment
		Social Equity
#17	**Water Cost**	**Economics**

Indicator Information

Data Coordinator: Paladino and Co., Inc.

Contact Person: Teresa Burrelsman

Baseline: EPACT / Seattle Plumbing Code

Supplemental Data: LEED Calculators

Indicator #3 Data

Water Rates, Tim Skeel, SPU Water Economist

Schedule

Start Measurements: First Quarter of 2004

End Measurements: Ongoing

Review Data: Quarterly

LEED Credits: Water Efficiency Credits 1, 2, &3

Indicator Description

This Indicator is a measure of avoided costs for water use in the building.

Both buildings are designed to save water, through natural landscape techniques, water-efficient fixtures, and rainwater harvesting for irrigation and toilet flushing. This indicator is a measure of the dollar cost corresponding to Indicator 3 Potable Water Use.

Indicator Methodology

Seattle Public Utilities provided rates forecasting for the next 25 years. These rates will be used to calculate the water cost savings of the project over time. Both wholesale and retail rates will be considered (See Indicator 18 for discussion). The forecasting takes into account a 2.5% inflation rate. The forecasts are prepared every five years with the next one occurring in 2005. The 2005 forecast will be used if it is available before the completion of the Performance Evaluation Plan.

Data Collection Table

Given anticipated future financial commitments, the system-wide average rate is expected to decrease in the near future, and then return to a peak of $2.84 per hundred cubic feet (ccf) of water in 2011 (Year 2000 dollars). This represents a forecasted growth rate of 8% per year between 2001 and 2005, with rates that follow the rate of inflation through 2020.

Projected Water Costs*	
Year	**Cost Per CCF****
2004	$2.84
2005	$2.75
2006	$2.79
2007	$2.72
2008	$2.74
2009	$2.76
2010	$2.82
2011	$2.84
2012	$2.77
2013	$2.71
2014	$2.68
2015	$2.66
2016	$2.61
2017	$2.55
2018	$2.54
2019	$2.50
2020	$2.47

*Source: 2000 Water System Plan, SPU

**Cost shown is in 2000 dollars

		Environment
#18	**Energy Cost Savings**	Social Equity
		Economics

Indicator Information

Data Coordinator:	Paladino & Co., Inc.
Contact Person:	Teresa Burrelsman
Baseline:	Seattle Energy Code Bldg.
Supplemental Data:	SCL Wholesale & Retail Price Forecast, Dennis Pearson, SPU Energy Analyst
	CO2 Environmental Cost Forecast
	Indicator #4 Data

Schedule

Start Measurements:	2004
End Measurements:	2005
Review Data:	Quarterly
LEED Credits:	Energy & Atmosphere Credit 1

Indicator Description

This Indicator is a measure of avoided costs for energy use in the building. The energy cost savings will be based on the energy savings in kWh documented under Indicator #4 Energy Savings. Seattle City Light has provided the energy rates that will be used to calculate costs or savings. If the Measurement and Verification Plan reveals significant data regarding gas energy consumption, then energy rates for therms will be obtained from Puget Sound Energy.

Indicator Methodology

The report will look at energy cost savings in two ways:

1. City Department's Electricity Cost Savings: This approach will use Seattle City Light's retail rates. The current average commercial rate is $0.068/kWh, as of October 2003. Specifically, the Justice Center is in the Large Network General Service rate class, with a 2003 weighted average (of peak & non-peak rates) of $0.0605/kWh. For City Hall, in the Medium Network General Service rate class, the weighted average rate is $0.641/kWh. The weighing factors are the number of days each of the three rate schedules (Jan.-Mar., April, May-Dec.) was in effect and the number of hours in the peak and off-peak time periods (6 a.m.-10p.m. peak, 10p.m.-6a.m. off-peak). Use of the retail rates in reporting energy savings allows individual departments to see the significance of investing in energy saving building technologies. It also presents results in a format useful to the private sector.

2. Marginal Social Cost Savings: Savings will also be presented from the total societal perspective, where the energy production or wholesale costs savings to Seattle City Light are combined with the 'marginal environmental cost of energy' savings. Environmental costs associated with energy production are the avoided CO_2 mitigation costs. The avoided cost of energy savings at the societal level will thus be expressed as the production or wholesale cost savings of $0.0385/kwh (whole cost in 2004 in 2003 constant dollars) plus the environmental cost of energy of $0.0218/kWh (2003), for a total of $0.060/kWh (2003 constant dollars). Seattle City Light has supplied 20 year forecasts of the retail, wholesale and avoided CO_2 mitigation costs. The present value (PV) of these cost savings will be calculated over a life of 25 years at real discount rates of 2% and 6%.

Seattle City Light has determined that conservation is cost effective, and has accounted for conservation in their retail rates forecast. This means that annual forecasted revenue from retail and wholesale energy sales, with conservation revenue loss included, will be sufficient to pay for all of the Utility's operating costs, capital improvements and scheduled debt repayment. Seattle City Light's Environmental Policy also states their commitment to promote and support the efficient use of materials and resources including water and electricity in all phases of a facility's life.

Data Collection Table – Energy Rate Forecast

Rates in Dollars per kW/H			
Year	Commercial Average	Justice Center, Large Network General Service*	City Hall, Medium Network General Service*	Marginal Social Cost**
2003	$0.0619	$0.0605	$0.0641	$0.0608
2004	$0.0619	$0.0605	$0.0641	$0.0577
2005	$0.0594	$0.0580	$0.0615	$0.0548
2006	$0.0608	$0.0594	$0.0630	$0.0571
2007	$0.0579	$0.0566	$0.0600	$0.0602
2008	$0.0563	$0.0551	$0.0584	$0.0636
2009	$0.0578	$0.0565	$0.0599	$0.0659
2010	$0.0590	$0.0577	$0.0612	$0.0675
2011	$0.0590	$0.0576	$0.0611	$0.0684
2012	$0.0614	$0.0600	$0.0636	$0.0696
2013	$0.0627	$0.0613	$0.0650	$0.0708
2014	$0.0624	$0.0610	$0.0647	$0.0720
2015	$0.0643	$0.0629	$0.0666	$0.0734
2016	$0.0647	$0.0633	$0.0671	$0.0748
2017	$0.0668	$0.0653	$0.0692	$0.0765
2018	$0.0669	$0.0654	$0.0693	$0.0783
2019	$0.0674	$0.0658	$0.0698	$0.0802
2020	$0.0687	$0.0672	$0.0712	$0.0823
2021	$0.0699	$0.0683	$0.0724	$0.0845
2022	TBD	TBD	TBD	$0.0869
2023	TBD	TBD	TBD	$0.0894
2024	TBD	TBD	TBD	$0.0920
2025	TBD	TBD	TBD	$0.0948
2026	TBD	TBD	TBD	$0.0977

All amounts are nominal, year 2000, dollars per kW/H, and were provided by Seattle City Light.

* Average of both peak and off-peak, in-city rate

** Marginal Social cost includes wholesale forecast prices plus plus the environmental cost of energy

#19	**Staff Overhead Costs, Related to Indoor Environmental Quality**	Environment
		Social Equity
		Economics

Indicator Information

Data Coordinator:	Personnel
Contact Person:	Lucia Athens
Baseline:	HR Data
Supplemental Data:	Compiled from Indicators #9-11
	Jackie Campbell, F&F, Buildings Manager

Schedule

Start Measurements:	Summer 2003
End Measurements:	Ongoing
Review Data:	Ongoing
LEED Credits:	All EQ Credits

Indicator Description

This Indicator is a measure of avoided costs for performance decrements experienced by employees due to poor indoor environmental quality.

In terms of an organization's annual operating expenses, initial building construction is a relatively small cost with big impacts. Per the Center for Building Performance and Diagnostics at Carnegie Mellon University's School of Architecture, physically housing employees and their work in an office building is typically less than $3,000-$5,000 per person per year. This includes lease/mortgage, utilities and facilities management costs. Small improvements in comfort, controllability, lighting and indoor air quality have a much larger economic impact over the life of a building, in terms of how those features support knowledge workers and staff.

Time employees spend on comfort complaints, or away from work due to illness is lost productive time for an employer. Turnover disrupts the normal workflow and requires time be taken to hire new employees. Administrative staff incurs work demand based on processing complaints, tracking absenteeism, hiring temporary workers if necessary, and hiring new employees due to turnover. Indicators 9 through 11 look at the number of complaints per year, absenteeism rates and employee turnover, which can act as a gauge of indoor environmental quality. The human resources costs associated with Indicator 9, 10, 11 and 12 will be expressed as a dollar amount under Indicator 19.

Indicator Methodology

The Personnel department is investigating a methodology for assigning a cost to staff turnover and staff time to respond to comfort complaints, as well as value for staff sick and time loss days. Any value assigned would be for comparison purposes only.

		Environment
#20	**Net Present Value of First Cost Increment & Savings**	Social Equity
		Economics

Indicator Information

Data Coordinator:	Paladino and Co., Inc.
Contact Person:	Teresa Burrelsman
Baseline:	None
Supplemental Data:	Compiled from Indicators # 3, 4, 9-11, 17 & 18
	Greg Hill, Department of Finance

Schedule

Start Measurements:	January 2004
End Measurements:	November 2005
Review Data:	Annually
LEED Credits:	N/A

Indicator Description

This Indicator is a measure of the present economic value of all the other indictor benefits, less the costs to produce them.

Green building strategies implemented in the City Hall and Justice Center will save the City money in operational costs over the life of the buildings. Each building incurred some additional cost to incorporate environmental elements that save operations costs, provide a better work environment and achieve a LEED Silver rating. The Net Present Value indicator looks at the incremental costs and the associated savings over the life of the building. This treats green building as an investment, identifying whether or not there is a positive rate of return for the City.

A recent study of state buildings by the State of California found that first cost investments of less than 2% yields life-cycle cost savings of over 10 times the initial investment. So far Seattle LEED buildings have seen 0.7% to 7% first cost increases due to LEED. As the City's project managers, and their design teams, gain experience, and start incorporating LEED and integrated design early in the design process, those costs have been closer to the low end of the range to pursue Silver LEED ratings. The purpose of this indicator is to determine the success of green building investment for the City of Seattle.

Indicator Methodology

Costs attributed to LEED construction beyond related codes, along with savings and/or costs identified by Indicators 17, 18 and 19, will be used to calculate the NPV of the City's first cost investment. Potential economic benefits will be presented in constant dollars (does not include inflation) using both a 2% and 6% real discount rate. The two rates are used to reflect cost-benefit discussions from two City perspectives: public sector/low risk and investment/private rate of return, respectively. These discount rates were selected in collaboration with Greg Hill of the Department of

Finance and the Evaluation Team. A 25-year life cycle will be used, as this is the time period the City uses in planning for major maintenance upgrades. No major rehabs to facilities are expected within the first 25 years.

Data Collection Table

Project Name	Total Project Budget	Estimated First Cost Add [%]	Estimated First [1] Cost Add [$]
Seattle Justice Center	$92,000,000	3.4%	$3,100,000 [2]
Seattle City Hall	$72,000,000	1.5%	$1,100,000 [3]

Notes:

1. First cost added may include non-LEED items.

2. Funding for LEED elements at the Justice Center was provided in part through Seattle City Light incentives, including $10K for commissioning, $385K for energy conservation measures and $28.4K for design assistance.

3. Funding for LEED elements at City Hall was provided in part by Seattle City Light and Seattle Public Utilities. SPU provided $280K for the rainwater harvesting system, through a Reuse Study Grant. SCL provided a commissioning rebate of $10K and $124K in energy conservation incentives.

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Measurement & Verification Plan

Data for several indicators will be collected through a comprehensive Measurement and Verification (M&V) Plan that measures ongoing energy and water performance at the building and system component level. Specifically, Indicators #3 Potable Water Use, #4 Energy Use, #17 Water Cost, and #18 Energy Cost are addressed in this M&V plan. The M&V plan sets forth a data collection strategy for various categories of building equipment than can be implemented periodically to validate anticipated performance expectations and identify potential system problems. The development and implementation of an M&V plan will also contribute to the achievement of a LEED point.

The goal of the M&V plan is to compare actual building performance both to predictions generated by an energy modeling process, and then to data collected on building performance in past data collection cycles. Discrepancies in the data that cannot be explained by weather or occupancy pattern variations may represent potential equipment performance problems. If a significant change were noted in the data, such as an unexplained spike in motor or fan energy consumption, this information could be used to direct efforts to diagnose and repair the specific cause.

The benefit of such a plan is two-fold. First, by identifying performance problem areas M&V often results in energy or maintenance cost savings over the life of the building. Second, data from M&V is required by the Performance Evaluation Plan to document the costs and benefits associated with LEED energy and water conservation strategies.

The development of an M&V plan is guided by standards set forth in the International Performance Measurement and Verification Protocol (IPMVP). This protocol lists specific categories that should be monitored, including:

- Lighting Systems and Controls
- Constant and Variable Motor Loads
- Variable Frequency Drive Operation
- Chiller Efficiency at Variable Loads
- Cooling Load
- Air Economizers
- Air Distribution Static Pressures and Ventilation Air Volumes
- Furnace Efficiencies
- Building-Specific Process Energy Systems
- Water Use

The M&V plans for specific buildings in the City of Seattle Portfolio have been developed to follow the guidelines identified in the IPMVP.

M&V Terminology

Code Baseline: This refers to a building performance baseline that was developed by the design team to demonstrate compliance with code requirements. It is an estimate of building energy use for a building that meets the requirements of the Seattle Energy Code. This energy use prediction will be used to compare actual building performance to code minimums.

Baseline Building: This energy model predicts actual building performance using an energy simulation. The model has been revised based on the final project design, so it varies somewhat from design-phase predictions. Also, the model has been specifically configured to correspond to data collection capabilities of the specific buildings. The baseline prediction uses average weather data to predict annual energy use.

Revised Baseline: This prediction is the same as the model above, except that the weather data used in the model corresponds to actual data from the monitored time period. If available, occupancy and other data from the monitoring period will also be incorporated into the revised baseline.

M&V Implementation Steps

The steps in implementing the Measurement and Verification plan for each building are as follows:

Step 1: Establish Predicted Baseline

An energy performance model of the buildings will be used to establish a performance baseline to compare to actual energy use. The baseline model has been developed using the eQUEST energy-modeling program, a variant of DOE-2.

The model was developed from as-built drawings of the projects, to more accurately identify energy performance characteristics of the completed buildings. To the extent possible, individual energy use parameters are set up in the model that parallel existing building control system monitoring capabilities. This allows the direct comparison of predicted and measured energy use data. Also, the model is configured to predict specific energy performance characteristics of those subsystems that can be directly monitored by the installed building control systems.

A more detailed description of the energy model baselines can be found in Appendix D: Energy Model Description.

Step 2: Set up Data Collection

The M&V process for each building will be initiated with a meeting of Building Operations staff from the city, and the energy modeling and M&V consultant. At this meeting, the specific data collection period for each individual data point will be identified based on software and programming capabilities of the building control system, and specific data output reports configured. The M&V consultant will work with city staff to set up report configurations in the building control systems. As the data collection reports are designed, final modifications of the data collection strategy will be adopted in response to specific capabilities of the control program.

Site visits will be scheduled for on-site data collection, and on-site protocols will be developed. A matrix of all data types collected, source, frequency, and related results will be developed at that time to help manage the data collection efforts. Data collection will be designed to coincide with utility billing cycles where this data is part of the evaluation protocol.

Step 3: Collect Building Performance Data

Data collection to support the M&V Plan will occur through four methods in this study:

1) Direct data collection by building automation systems for the specific performance period

   This data collection effort will be configured differently for each building depending on the capabilities of the building control system. At the initiation of the data collection effort, it will be necessary to program the building control system to specifically record the desired information at designated intervals.

   Information about building HVAC system operation will be the primary category of data collected from the building control system.

2) On-site study protocols implemented periodically during the study period

   Data that cannot be collected by the building control systems will be gathered on-site. Information about lighting systems and controls, office equipment energy use, and occupancy will be gathered primarily by on-site protocols. These protocols will involve data collection using hand-held equipment and observation, depending on the type of information desired. Specific data collection protocols will be developed after the abilities of the automated control

system are clearly identified in the programming phase of method 1 above.

3) Data collection and analysis by other parties to the PEP effort

Several concurrent studies are planned or underway by other organizations. These include a daylighting analysis by the Daylighting Lab in Seattle, and a study of workstation characteristics and double wall performance undertaken by the Center for the Built Environment (CBE). Information gathered by these studies will have a tangential relationship to the M&V effort, but key findings will help inform the M&V process.

4) Data derived from related indicators

Information about staffing levels, absenteeism, building use schedules, etc., may need to be estimated from other data sources at the city.

For each building in the study, specific data collection capabilities of the building control system have been identified. These capabilities have been used in part to inform the configuration of the energy use prediction models. To the extent possible, the models are designed to predict energy use information in categories that can be cross-referenced to measured data. Data collection capabilities for each building are identified in the building-specific M&V plans at the end of this section.

Metered Energy Use

In addition to individual energy use categories, overall building energy use will be monitored. For electric energy use, this data will be tracked using the Seattle City Light's Seattle Meter Watch (http://smw.seattle.gov) real-time energy use monitoring service. Gas consumption will be monitored either by the building control system (pulse meter at Justice Center) or by reviewing utility bills for the project over the period of evaluation (City Hall).

Total building metered energy use will provide a critical reference for validating overall performance projections of the energy use model and on-site predictions.

Water Use

Water use data for the building will also be collected. This data will come from several sources, including utility water meter monthly data, building control system monitoring, and sub-meters for irrigation and toilet water use. In addition, data from

regional sources will be used to accurately characterize roof water collection and irrigation needs.

Step 4: Revise Predicted Baseline to Reflect Actual Conditions

The energy performance model will be modified to reflect actual conditions experienced during the data collection period.

Weather

Energy performance predictions that are based on energy modeling use weather data collected over 30 years, averaged to represent a typical meteorological year (TMY). Although this data represents a good prediction of average weather conditions, annual variation in weather can lead to significant variations in actual building energy use. In order to more closely correlate predicted and actual energy use characteristics, the model will be run with actual local weather data collected during the same time period as the building monitoring. This will reduce the effect of annual weather variability on building energy performance estimates.

This weather data will include temperature, humidity, rainfall, and insolation data collected at local weather monitoring sites, or by building control systems as available. This data can be collected directly from the National Oceanographic and Atmospheric Administration for local sites for any given time period.

Occupancy & Other Data

Building occupancy levels have a significant effect on building energy performance characteristics, and represent a variable that can cause large fluctuation in predicted energy use. To improve the accuracy of energy use predictions, it will be necessary to estimate daily occupancy levels over the course of the measurement period.

This data is not tracked directly by the city, so estimates will have to be developed based on overall employment levels, holiday schedules, and absenteeism rates. The City will be tracking absenteeism rates as one of the proposed indicators of this study, so it may be possible to convert this data into occupancy projections for the projects. Additional on-site occupancy spot checks may be necessary during the evaluation period to estimate transient occupant use.

Step 5: Comparison and Analysis

Once the steps above have been completed, the data collected from various sources will be compared and analyzed. The first

task will be to compare overall metered energy use to total energy use predicted by the energy model. The degree of difference between the predicted and actual energy use will determine the extent to which more in-depth evaluation is necessary. As a guideline, a difference of over 10% between measured and predicted energy use will trigger more extensive review of individual energy use characteristics than would be necessary if predicted and actual energy use are more in line with each other. This review will focus first on underlying assumptions about building occupancy and use schedules, as this information can have a significant affect on total energy performance.

Next, data will be compared from individual energy use categories that are directly comparable between the modeled and monitored data. In this stage of the evaluation, the goal will be to identify energy use categories that represent either a large percentage of total energy use, or a significant divergence in actual and predicted energy use. These two variables will be combined to identify a 'significance factor' that will help focus research and performance improvement efforts on more important categories of energy use based on findings of the M&V effort. Table 4.1 provides a template for how the significance of component energy use and divergence from predicted results will be compared.

The results of the sensitivity analysis will suggest areas of the building that require further study. Systems which are not performing as anticipated will be reviewed more extensively to identify potential operational problems associated with this equipment. Systems that represent a large percentage of total energy use will be targeted for operational improvements that might reduce energy demand.

Table 4.1: Sensitivity Analysis (Blank Template)

Data Category (examples)	Measured Consumption	Predicted Consumption	% Variation	% of Total Energy Use	Significance Factor
Fan Energy					
Lighting Energy					
Boiler Energy					

Step 6: Reporting

Data collected will be processed and presented in quarterly updates during 2004 and 2005. Analysis will compare predicted and actual energy use for the monitoring period, and identify key areas of divergence. This will allow a subsequent, more focused evaluation of any systems where there may be

operational problems, or where the opportunity exists for improved energy performance. Reporting will include overall energy savings with respect to the predicted and baseline energy use assumptions.

Results of data analysis and evaluation will be presented in annual reports, at the end of 2004 and 2005, in conjunction with the Seattle LEED Performance Evaluation Reports.

City Hall M&V Data Collection Plan

Overall Energy Use

Total building energy consumption indicated on building utility bills for the evaluation period will be compared to energy use predictions generated by the energy model. This will provide the first pass evaluation of building energy use, and will be the starting point for evaluation of category specific energy use described in the sections below.

At City Hall, electrical consumption and peak demand are monitored by the building control system, so this data can be compared directly to model predictions. Alternately, real-time energy use and trends can be monitored directly through Seattle City Light.

Currently, the City Hall building control system does not have the capability of monitoring natural gas use. Although this capacity could be added, it would be just as effective to review natural gas utility bills to obtain this data. In order for utility billing data to be used in this analysis, the on-site data collection period will need to correspond directly to a utility billing periods.

Lighting

Lighting energy is not monitored by the building control system. Lighting energy use will need to be calculated from site collected data and construction or as-built documentation. Three data types will be used to generate an estimate of lighting energy use.

1)   Lighting Power Density (LPD, in watts/sf) will be calculated based on the number and types of fixtures installed in the building. This will require a lighting take-off from the as-built plan set to determine total connected lighting load.

2)   Actual fixture use will be estimated by conducting site visit audits focusing on fixture use patterns. A subset of space types will be audited to identify what percentage of the fixtures is in use on a typical day. This ratio will be applied to the installed LPD to determine an effective LPD. Spaces with specialized lighting controls (daylight sensors or occupancy sensors) will be evaluated independently.

3)   This data will be augmented by data loggers installed in several key locations. The purpose of the data loggers will be to monitor light levels at these locations. This information will allow independent verification of occupancy assumptions, and may figure into calculations involving the daylight controls.

The above information will be used to generate an estimate of total lighting energy consumption, in kWh, for the evaluation period. The energy model includes specific predictions of lighting energy use, so this data will be compared with model predictions to verify lighting system performance.

Plug Loads

Data on plug loads will be collected through an on-site audit implemented once during the monitoring period. The purpose of the survey is to characterize average plug load by space type. This information will be used to calibrate the plug load component of the energy model.

HVAC

Most of the HVAC performance data will be collected directly by the building control system. The data will fall into four primary energy categories: Fan, boiler, chiller, and pump energy.

Table 4.2 describes the relevant data collection capabilities of the building control system, and describes how this data will be evaluated to compare predicted and actual energy use.

In order to collect this data, it will be necessary to work with city staff or the controls consultant to program the desired data collection frequencies and report format into the control system. This process may lead to some modifications in the data collection strategy identified in Table 4.2. Data collection frequency for specific data points will be determined based on the overall software and memory capacity of the building control system.

Stormwater

The City will implement a series of storm water monitoring capabilities to evaluate the system and environmental impacts of the stormwater system. The design of a comprehensive rainwater monitoring system for City Hall is in progress, slated for completion in early 2004 in time for construction of the rainwater collection system in the plaza.

The City Hall rainwater plan will accommodate measurement of the water level in the cistern and any overflow. Sensors in the cistern will take measurements and the data will be relayed to the digital control system that will collect water data over time.

This data will be compared to LEED calculations to determine the amount of stormwater savings vs. code compliant design. Water diverted from the city stormwater system will be expressed in gallons per year.

Water

The City Hall has implemented a number of water saving features that go beyond code minimums. The City will implement a series of water use monitoring capabilities to evaluate total potable water use.

The LEED calculators for irrigation and fixture use will be used to establish expected water savings. These calculators use standard irrigation practices and standard code compliant fixtures as a baseline by which to compare potable water use.

Data on the total water use, toilet water use and irrigation water use will be collected via digital control meters installed at the building. This data will be used to refine the water savings calculations from the LEED calculator for City Hall. Water savings will be expressed in gallons per year.

Table 4.2: City Hall Control System Data Points

City Hall			
Data Point	**Units**	**Collection Frequency**	**Correlation w/ energy model**
Fans			
Power input	kW	TBD	Compare fan energy use/verify fan curve assumptions
Static pressure	In. H2O	TBD	Verify fan curve assumptions for model
Outside air flow	CFM	TBD	Verify ventilation rate
Total air flow	CFM	TBD	Verify fan curve assumptions for model
Supply air temperature	°F	TBD	Compare to boiler/chiller energy use, estimate duct loss
Return air temperature	°F	TBD	Compare to boiler/chiller energy use, estimate duct loss
Zone inlet air flow	CFM	TBD	Isolate zone-specific energy use
Zone inlet temperature	°F	TBD	Estimate duct loss
Pumps			
Pump flow	GPM	TBD	Verify pump energy predictions
Pump pressure	PSI	TBD	Verify pump energy predictions
Circulation loop temperature	°F	TBD	Compare to boiler/chiller energy use
System flow rate	GPM	TBD	Verify pump energy predictions
Zone flow rate	GPM	TBD	Isolate zone-specific energy use
System inlet temperature	°F	TBD	Compare to boiler/chiller energy use, estimate supply pipe loss
System outlet temperature	°F	TBD	Compare to boiler/chiller energy use, estimate return pipe loss
Chiller			
Entering water temperature	°F	TBD	Cross-check with hourly temp. and flow to validate chiller efficiency assumptions, estimate return pipe loss
Leaving water temperature	°F	TBD	Cross-check with hourly temp. and flow to validate chiller efficiency assumptions, estimate supply pipe loss
Chilled water flow	GPM	TBD	Cross-check with hourly temp. and flow to validate chiller efficiency assumptions
Boiler			
Inlet water temperature	°F	TBD	Determine boiler energy use, estimate return pipe loss
Outlet water temperature	°F	TBD	Determine boiler energy use, estimate supply pipe loss
Hot water flow	GPM	TBD	Determine boiler energy use
Water Use			
Toilet Water Use	Gallons	TBD	Determine gallons/year for toilet use
Irrigation Water Use	Gallons	TBD	Determine gallons/year for irrigation use

Justice Center M&V Data Collection Plan

Overall Energy Use

Total building energy consumption indicated on building utility bills for the evaluation period will be compared to energy use predictions generated by the energy model. This will provide the first pass evaluation of building energy use, and will be the starting point for evaluation of category specific energy use described in the sections below.

At Justice Center, electrical consumption is monitored by the building control system, so this data can be compared directly to model predictions. Peak demand is not monitored by the control system, and will need to be gathered from utility bills or on-line through Seattle City Light's real-time energy use and trend monitoring tool.

The Justice Center building control system also has the capability to monitor natural gas use.

Lighting

Lighting energy is not monitored by the building control system. Lighting energy use will need to be calculated from site collected data and plan-set information. Three data types will be used to generate an estimate of lighting energy use.

1)   Lighting Power Density (LPD, in watts/sf) will be calculated based on the number and types of fixtures installed in the building. This will require a lighting take-off from the as-built plan set to determine total connected lighting load.

2)   Actual fixture use will be estimated by conducting site visit audits focusing on fixture use patterns. A subset of space types will be reviewed by auditors to identify what percentage of the fixtures are in use on a typical day. This ratio will be applied to the installed lighting power density to determine an effective LPD. Spaces with specialized lighting controls (daylight sensors or occupancy sensors) will be evaluated independently.

3)   This data will be augmented by data loggers installed in several key locations. The purpose of the data loggers will be to monitor light levels at these locations. This information will allow independent verification of occupancy assumptions, and may figure into calculations involving the daylight controls.

The above information will be used to generate an estimate of total lighting energy consumption, in kWh, for the evaluation period. The energy model includes specific predictions of lighting energy use, so this data will be compared with model predictions to verify lighting system performance.

Plug Loads

Data on plug loads will be collected through an on-site audit implemented once during the monitoring period. The purpose of the survey is to characterize average plug load by space type. This information will be used to calibrate the plug load component of the energy model.

HVAC

Most of the HVAC performance data will be collected directly by the building control system. The data will fall into four primary energy categories: Fan, boiler, chiller, and pump energy.

Table 4.3 describes the relevant data collection capabilities of the building control system, and describes how this data will be evaluated to compare predicted and actual energy use.

In order to collect this data, it will be necessary to work with city staff or the controls consultant to program the desired data collection frequencies and report format into the control system. This process may lead to some modifications in the data collection strategy identified in Table 4.3. Data collection frequency for specific data points will be determined based on the overall software and memory capacity of the building control system.

Water and Stormwater

Water use at the Justice Center will be monitored through utility bill evaluation and spot checks during the evaluation period. No specific, on-going measurement equipment will be installed. Water monitoring equipment was not included in the project during design and construction phases.

Table 4.3: Justice Center Control System Data Points

Justice Center			
Data Point	**Units**	**Collection Frequency**	**Correlation w/ energy model**
Fans			
Power input	kW	TBD	Compare fan energy use/verify fan curve assumptions
Static pressure	In. H2O	TBD	Verify fan curve assumptions for model
Outside air flow	CFM	TBD	Verify ventilation rate
Total air flow	CFM	TBD	Verify fan curve assumptions for model
Supply air temperature	°F	TBD	Compare to boiler/chiller energy use, estimate duct loss
Return air temperature	°F	TBD	Compare to boiler/chiller energy use, estimate duct loss
Zone inlet air flow	CFM	TBD	Isolate zone-specific energy use
Zone inlet temperature	°F	TBD	Estimate duct loss
Pumps			
Pump flow	GPM	TBD	Verify pump energy predictions
Circulation loop temperature	°F	TBD	Compare to boiler/chiller energy use
System flow rate	GPM	TBD	Verify pump energy predictions
System inlet temperature	°F	TBD	Compare to boiler/chiller energy use, estimate supply pipe loss
System outlet temperature	°F	TBD	Compare to boiler/chiller energy use, estimate return pipe loss
Chiller			
Compressor Power Input	kW	TBD	Cross check with predicted energy use
Condenser Power Input	kW	TBD	Cross check with predicted energy use
Entering water temperature	°F	TBD	Cross-check with hourly temp. & flow to validate chiller efficiency assumptions, estimate return pipe loss
Leaving water temperature	°F	TBD	Cross-check with hourly temp. & flow to validate chiller efficiency assumptions, estimate supply pipe loss
Chilled water flow	GPM	TBD	Cross-check with hourly temp. & flow to validate chiller efficiency assumptions
Boiler			
Inlet water temperature (pending)	°F	TBD	Determine boiler energy use, estimate return pipe loss
Outlet water temperature (pending)	°F	TBD	Determine boiler energy use, estimate supply pipe loss
Hot water flow	GPM	TBD	Determine boiler energy use

LEED Performance Reporting

Data Processing & Analysis

Paladino will collect the data as outlined in Section 3 Data Collection Methodology and Section 4 Measurement and Verification. For some indicators, data collection has already begun; the main measurement period however is January 2004 through November of 2005. For most indicators, data will be processed on a quarterly basis. Quarterly updates will be compiled for analysis.

Performance Reports

To assess progress, collected data on LEED project performance will be compared to the related baselines. The Building Performance Report will highlight quantitative data such as energy and water consumption, and qualitative data such as occupant surveys on comfort and satisfaction, as well as cost and savings information. The data will be presented in a standardized format, to accommodate future projects so that various City projects can be compared to each other and to the baseline on an on-going basis.

The performance of Seattle LEED projects against the 20 indicators presented in Section 1 will serve as a benchmark of the City's progress in sustainable building. Reports will be compiled annually.

- Interim Performance Report – December 2004/January 2005

- Final Performance Report – December 2005

Economic Benefits

Economic benefits will be presented using both a 2% and 6% (real) discount rate, to reflect cost-benefit discussions from the public sector/low risk perspective and from the investment/private rate of return perspective. These discount rates were selected in collaboration with Greg Hill of the Department of Finance. A 25-year life cycle will be used, as this is the time period the City uses in planning for major maintenance upgrades. No major rehabilitations to facilities are expected within the first 25 years.

Indirect Benefits

Environmental and social benefits, or 'indirect' benefits, will be expressed in the units outlined in the data collection methodologies in Section 3 for each indicator. Graphs, charts and

Workstation Visual Field

Glare within the visual field results in discomfort and eyestrain. In this instance, occupants have used an umbrella to mitigate glare from insufficiently shaded windows. Visual discomfort also reduces worker effectiveness

diagrams will be used to convey the relative differences between the LEED case and a Seattle baseline.

Post Report - Future Steps

▪ Provide Education and Outreach: Educate city project managers through training and data sharing tools. Also extend education to the private sector, through presentations, case studies and cost-benefit data.

▪ Develop Guidelines & Standards: Based on performance of various LEED strategies, identify priorities for funding and incentives, and develop guidelines for implementation of LEED on future City projects. Integrate results of LEED Performance Evaluation into the City's IMPLEMENT on-line design tool.

▪ Build Institutional Memory: Compile data regarding the green building strategies, products and methods used in the City's LEED buildings. Add this data to the City's IMPLEMENT on-line design tool.

Appendix A: Daylighting Studies

In conjunction with Indicator 12 Access to Daylight and Indicator 13 Visual Comfort Analysis, the Daylighting Design Lab (DDL) performed an analysis of three buildings:

1. Municipal Building, City Hall Baseline

2. City Hall

3. Justice Center

Municipal Building

The Daylighting Design Lab analyzed the daylighting conditions in the Municipal Building in June, 2003. This report detailed the existing working conditions prior to the move into the City Hall building. Daylighting and electric lighting levels throughout the building are documented as well as the glare conditions that existed at several workstations. In order to model seasonal variations, Paladino constructed a scaled model for study in the DDL's heliodon. Indicators 12 & 13 will use the Municipal Building report as a baseline to compare daylighting conditions in the new City Hall.

City Hall

A daylighting analysis of City Hall is in progress. Studies were conducted in November, 2003, and will be concluded in early 2004. This study will be used in conjunction with the analysis already performed on the Municipal Building in order to assess Indicators 12 & 13.

Seattle Justice Center

The Daylighting Design Lab in conjunction with a graduate class from the University of Washington has analyzed visual comfort conditions in the Seattle Justice Center. Their report documents the lighting conditions of the 5th floor by measuring light levels and glare in cubicles along the West facing glass facade. Included are surveys that ask employees about their perceptions of the lighting conditions. A second report documents lighting conditions inside a courtroom located on the south side of the building. Specifically studied is the penetration of sunlight in the winter months.

There is no baseline for the Justice Center, as the move of both personnel and furnishings from the Public Safety Building was completed prior to the development of the Performance Evaluation Plan.

Daylighting Report Files

The reports completed as of December 2003 are included on the accompanying CD:

DDL_MUNI Building Final.pdf

DDL_SJC Office Daylighting.pdf

DDL_SJC Courts Daylighting.pdf

Appendix B: Building Surveys

Judith Heerwagen and Associates was contracted to conduct a pre-occupancy survey of the previous City Hall building, the Municipal Building, and a post-occupancy survey of the new City Hall. The pre-occupancy survey will provide a baseline for comparison with conditions at the new City Hall, and was completed in the Summer of 2003 prior to tenant moves to the new City Hall. The post-occupancy survey will be conducted in the first quarter of 2004, once tenants have occupied the new City Hall for approximately 8 to 9 months. The initial 6 months of a newly constructed or renovated building's occupancy generally involves fine-tuning and adjustments of building systems, and surveys and other studies should generally be completed after this period. The demolition of the Municipal Building, which currently shades the West façade of the Municipal Building, will also be completed by that time. The two reports will be used in conjunction with each other to measure indicators 13, 15 & 16.

The surveys for both buildings use identical questions that were developed by the Center for the Built Environment to assess workplace satisfaction. The survey asks respondents about their perceptions of comfort or discomfort in relation to lighting, glare, indoor air, temperature and other environmental factors. The Appendix CD contains the survey questions, and the preliminary results from the Municipal Building survey.

Building Survey Files

The Municipal Building Survey results are available for internal City of Seattle review only. The website address, username, and password are located in a text file on the accompanying CD. Also included are a survey description by Judith Heerwagen Associates, excerpts from the website, including overall method and score summary, and the survey questionnaire.

JHA_Municipal Bldg Survey Prelim Results_Readme.txt

JHA_Survey Description.doc

JHA_Survey Report_City Hall PreOccupancy Scores.mht

JHA_Survey Report_Methodology.mht

JHA_CBE Building Survey Questionnaire.pdf

Appendix C: Center for the Built Environment Study

Seattle Justice Center Post-Occupancy Evaluation

The Center for the Built Environment (CBE) is currently researching various building performance issues, including their research study "Evaluating Perimeter Zone and Façade Performance." They have developed tools and criteria to evaluate perimeter zone environments, and will use findings to improve design tools and methods.

As part of this project, the CBE is conducting an independent third party analysis of the thermal performance of the double-skin wall at the Justice Center. They have installed equipment to measure temperature and airflow in the thermal buffer zone between the panes of glass as well as interior conditions adjacent to the wall. The data collected will be used to substantiate energy measurements and modeling by other consultants working on this performance evaluation plan. Indicators 12, 13 & 14 will use the collected data as a source for evaluation. In addition, the CBE will conduct employee surveys and take luminance, glare and daylighting measurements to assist with the corroboration of measured data and perceived conditions. The final evaluation report is currently in progress.

CBE Study Files

A measurement plan from the CBE is provided on the accompanying CD. Also included is a Powerpoint presentation by Robert Marcial and Edward Arens at the CBE about the study.

CBE_JC Double Skin Wall Study.pdf

CBE_JC Evaluating Façade Performance Oct 2003.ppt

Appendix D: Energy Modeling

Energy Modeling Description

Madison Engineering has provided a description of how the building design phase energy models were evaluated and revised based on final building design conditions. These revisions were necessary to account for actual energy performance parameters that are ignored or modified from actual building conditions by the requirements of the City of Seattle Energy Code.

Energy Modeling for Measurement and Verification – Introduction

Energy analysis of buildings during the design phase relies heavily on assumptions about expected use of the building and performance of its systems. Measurement and verification after the building is occupied can be used to verify and revise energy use estimates by applying measured (or at least observed) operating and performance characteristics.

If the purpose of the energy analysis was to demonstrate energy code compliance, there are most likely energy using features of the building that are not considered in the energy analysis due to restrictions in the analysis requirements or codes applicable to the project (Seattle Energy Code RS-29). Even though these features cannot be considered in the energy code analysis, they can have significant effects on building energy use and, if not eventually considered in the analysis, can confound calibration of an energy model to actual energy use. Piping losses, duct losses and leakage and automatic lighting controls are examples of energy design characteristics of buildings that cannot be considered in the energy analysis but have significant impacts on energy use.

Calibration of an existing energy model through measurement and verification can be achieved through the following steps:

1) **Confirm Proposed Model Matches Construction Documents:** Revisions and change orders typically occur after the energy analysis is considered "complete." As built plans should be reviewed and the proposed building model should revised as needed. Also, features not considered in the original analysis such as pipe/duct losses and lighting controls should be added to the model.

2) **Determine Appropriate Measurements:** A list of measurements needed to verify building system performance should be prepared.

3) **Determine Appropriate Baseline Building:** At a minimum, a general guideline of what the baseline should consider should be prepared. For example, are there standard practice assumptions for piping losses?

4) **Utilize Measured Data to Calibrate Proposed Model to Actual Energy Use.**

5) **Apply Appropriate Calibrated Proposed Building Features Into Baseline:** At a minimum, observed occupancy characteristics and performance characteristics of identical building systems (e.g., an identically configured fan) should be incorporated into the baseline building model.

Energy Model Revisions – Seattle Justice Center

Seattle Energy Code compliance for the Justice Center was achieved using RS-29 (computer simulation approach). The baseline energy model for this building will be similar to the proposed building, except that features of the proposed building that do not comply with prescriptive requirements of the SEC are modified to comply. Additionally, features that exceed SEC requirements in the proposed building, are modified to barely meet requirements in the baseline building.

The primary features of the proposed building that do not meet SEC requirements are:

1) Glazing percentage is approximately 54% of gross exterior wall area compared to a maximum of 40% allowed in the SEC

2) Hydronic heat pumps do not have air economizers

The primary features of the proposed building that exceed SEC requirements are:

1) Anticipated glazing U-factor and SHGC of the thermal buffer glazing system are about 0.23 and 0.3 respectively.

2) Installed lighting power is about 30% less than minimum SEC requirements

3) Boilers are 92% efficient compared to SEC requirements of 80%

4) Demand controlled ventilation using CO_2 monitoring allows for reduction of outside air during low occupancy periods reducing heating and cooling energy when economizers are not operating

In addition to Seattle Energy Code features described above, automatic daylighting controls and occupancy sensors are used whenever possible. While the SEC does not allow these controls to be considered in the energy code analysis, they will reduce energy use considerably over conventional wall switch/time clock controls. Occupancy sensors are simulated using a modified lighting schedule, while daylighting controls are simulated using daylighting capabilities of the energy simulation software.

The energy model for the Justice Center has been regenerated using eQUEST energy simulation software. eQUEST has capabilities to more accurately simulate many building features including:

1) Fan powered terminal units for HVAC air distribution

2) Multiple circulation loops for hot, chilled and condenser water circulation

3) Complex pumping system configurations such as constant primary flow/variable secondary flow for hot water systems

4) Circulation loop (hot water/chilled water) pipe losses to other spaces in the building

Many features of the eQUEST model are identical or very similar to the original model including:

1) Building operating schedules (lighting, occupancy, infiltration, HVAC)

2) Building envelope thermal performance

3) Shading from other structures (on-site parking structure, King County Administration Building, City Hall, etc.)

Actual operating schedules and parameters will be entered into the model during the measurement phase of the project.

Below is a graphical representation of the Justice Center as it appears in the eQUEST detailed user interface.
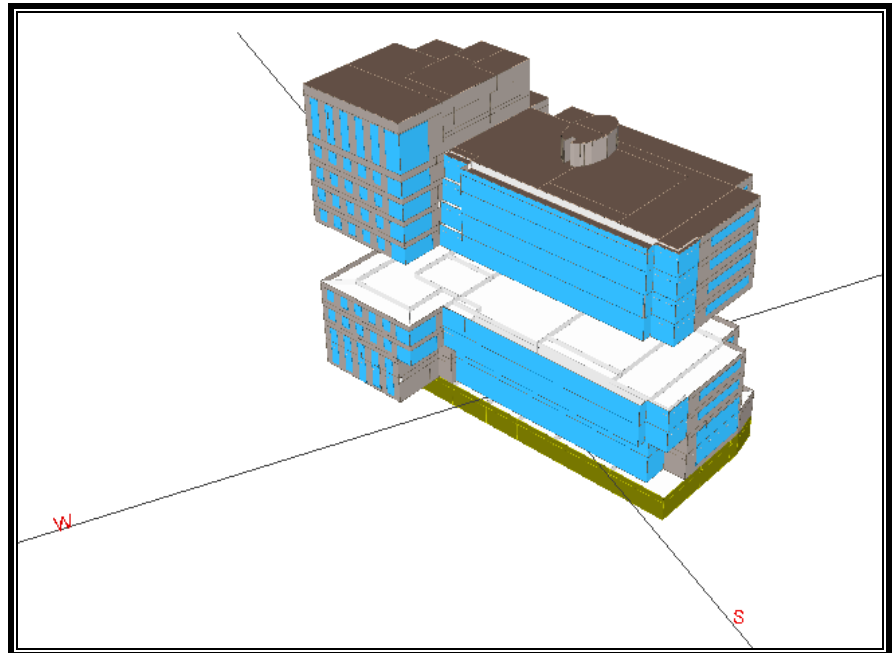
Energy Model Revisions – Seattle City Hall

SEC compliance for the City Hall was demonstrated using component performance approaches. Energy simulation was performed only achieve LEED energy performance credits. The table below describes important differences and similarities between baseline and proposed energy models used to determine energy performance above an SEC baseline.

Feature	Baseline Assumptions	Proposed Assumptions
Building envelope	As designed (1)	As designed
Lighting	Per SEC requirements	As designed
HVAC	Per SEC requirements (2)	As designed

Notes:

1 - Since the building complied using the component performance approach, it is assumed that modifications to the envelope to achieve prescriptive requirements would have negligible energy use impacts

2 - Baseline fan static pressure increased by one third over actual design for under-floor distribution systems – see table below.

Similar to the Justice Center, lighting energy savings in the City Hall is also achieved through extensive use of automatic daylighting controls and occupancy sensors. These savings would not be considered in an energy code analysis, but should be considered in the measurement and verification of building energy use.

The original energy model for the City Hall is largely adequate for the measurement and verification project. The model has been revised to reflect differences between the model and the construction documents. Differences between the model and construction documents appear to be due to revisions in the construction documents that occurred after the energy model was considered complete. Below is a table describing the revisions to the energy model and how the energy use is expected to change.

Seattle City Hall				
Property	**Original Value**	**Proposed Revision**	**Reason**	**Expected Impact (1)**
Heating Setpoint	70F	Lower (68.5F)	stratification effects of under-floor distribution	lower heating energy
Cooling Setpoint	75F	Higher (76.5F)	stratification effects of under-floor distribution	lower cooling and heating (reheat) energy
Air distribution system	standard VAV	series fan powered VAV	per construction documents	negligible given lower static pressure (see next)
Fan power	~5.5" total static	revise baseline energy use to be 33% higher	per SEC credit **(2)**	lower fan energy – unsure of impact of series fan-powered terminal units (above)
Hot water distribution	constant flow	variable flow distribution, constant flow through boilers	per construction documents	lower pumping and heating energy
Chilled water distribution	variable flow distribution, constant flow through chiller	primary variable flow	per construction documents	lower pumping and cooling energy
Boiler plant	single boiler	two boilers	per construction documents	lower heating and hot water pumping energy
Chiller plant	single chiller	two chillers	per construction documents	lower cooling energy
Piping losses	ignored	temperature rise/drop due to losses based on eventual field measurements	particularly significant during part-load operation	increase in heating and cooling energy
Duct losses (conductive and leakage)	ignored	temperature rise/drop and percent leakage based on eventual field measurements	Leakage will impact heating/cooling/fan energy	increase in heating, cooling and fan energy

Notes:

1. Operating schedules, operating parameters and equipment performance for the energy models will be finalized during the measurement and verification phase. Schedules and operating parameters will be used in both the proposed and baseline (Seattle Energy Code minimum) energy models to determine the actual savings of the proposed building beyond the baseline building.

2. The Seattle Energy Code RS-29 allows a 25% reduction in fan energy use when under-floor air distribution systems are used. This credit will be implemented by increasing the baseline fan static pressure by 1/3 over the actual static pressure.